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Cyclopedia
of
Fire Prevention and Insurance

A General Reference Work

ON FIRE AND FIRE LOSSES, FIREPROOF CONSTRUCTION, BUILDING INSPECTION, INSPECTORS' REPORTS, PRIVATE AND PUBLIC FIRE PROTECTION, COMMON AND SPECIAL HAZARDS, CHEMISTRY OF COMBUSTION, UNDERWRITERS' REQUIREMENTS, FIRE INSURANCE LAW, THE STANDARD POLICY, RATING, UNDERWRITING, BROKERAGE, SETTLEMENT OF LOSSES, ETC.

Prepared by

ARCHITECTS, ENGINEERS, UNDERWRITERS, AND PRACTICAL INSURANCE MEN

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THE following list of books on the subjects of Fire Prevention, Fireproof Construction, and Fire Insurance is not intended to be complete, but represents the best book literature in the field. Unfortunately, on account of lack of space, the many short pamphlets, addresses, and reprints from periodicals, containing a wealth of authoritative information, cannot be included. For these the reader is referred to the annuals and quarterlies of the various fire and insurance organizations and to the libraries.

Regarding annual and quarterly publications, it should be mentioned that annual volumes are published by the Fire Underwriters' Association of the Pacific, the Fire Insurance Society of San Francisco, the Fire Underwriters' Association of the Northwest, the Fire Insurance Society of Philadelphia, and the Insurance Institute of Hartford, while the Insurance Library Association of Boston publishes a quarterly bulletin containing the best index to insurance literature printed, the Fire Insurance Society of Chicago publishes a bulletin during certain months of the year, and the Insurance Society of New York publishes occasional bulletins. In England the Chartered Institute, formerly the Insurance Institute of Great Britain and Ireland, publishes, through C. R. Layton, London, England, an annual volume called The Journal. Along fire prevention lines two important series of publications should be mentioned, viz, the Annual Report and supplemental pamphlets of the National Board of Underwriters, and the annual and quarterly of the National Fire Protection Association, 87 Milk Street, Boston.

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Foreword

ABOUT two hundred and fifty years ago a man named Nicholas Barbon, following the marine practice of many years' standing, conceived the idea of broadening the risk to include fire in buildings or their contents. To each property owner who desired it, he guaranteed reimbursement up to a certain amount in case of loss, accepting in exchange for the responsibility of this risk an annual payment of a certain small amount called the premium. This was the beginning of the fire insurance business. Today, by the application of the law of averages and other scientific principles, what was at first a mere gamble has become a real co-operative business arrangement by which a host of owners pay yearly a small but carefully calculated sum to the insurance companies in order that the certain number of owners who are bound to be visited by fire during the year may be reimbursed for their losses. The insurance business has grown amazingly, until now it represents millions upon millions of capital, controls a vast army of employes, and covers almost every conceivable form of risk.

¶ And yet it is evident that a fire insurance policy does not represent the last word on the subject of protection. At best it is only financial protection and can be of no help in preventing the building from catching fire or from burning up. The payment of the loss by the insurance company may enable the owner to rebuild as good as new, but the useful material which has been reduced to impotent ashes can never be restored. Every fire, then, is a waste of the world's energy, and the yearly total of fire losses reaches such a staggering sum, particularly in this country, that a continuance of such annual sacrifices would seem to mean the possibility of our ultimate financial ruin. The principle of "conservation of the world's resources" demands a more rational method of procedure, namely, the construction of buildings of materials that *cannot* burn. Notwithstanding this most obvious conclusion, it is within the memory of many a man of today—and not the "oldest inhabitant" either—that the first real steps were taken to make use of methods and materials in building construction which would safeguard the building against this terrible destroyer.

¶ Strange as it may seem, it took years of strenuous effort on the part of the believers in this principle of fire *prevention* before the movement could gain sufficient headway to become a potential force in the constructive activity of this country. The insurance policy—the easy road to financial reimbursement—was too alluring. Our forests seemed inexhaustible. Lumber was cheap and easily obtained, while steel and tile, concrete, and other fireproof materials were too expensive to be considered. In fact, the world had to suffer several serious conflagrations and in the end the owner, the architect, and the contractor had to be *compelled* by proper municipal legislation to build according to fire protective specifications before much progress could be made.

¶ The effect of this restrictive legislation is shown in its most complete form in Europe, where the broader area of the congested districts and the scarcity of lumber have forced the problem to its natural solution much earlier than in this country. The wonderfully effective "neighboring risk" idea, by which each owner is made liable for damage to his neighbor's property through fires due to his own carelessness or to the neglect of proper preventive methods, has also helped to stimulate the rapid adoption of the protective measures, resulting in fire losses per capita in different parts of Europe which are from six to twenty times lower than the figure for this country, and this, too, in the face of a much denser population.

¶ However, the cause of fire prevention and the appreciation of fireproof construction has progressed very rapidly in the United States during the last few years. The establishment of Boards of Underwriters, the development of Underwriters' Laboratories, where fire preventive appliances may be tested and certified to, the good work of the National Fire Protection Association and of the New England Factory Mutuals, and the earnest co-operation of the insurance companies with these seemingly antagonistic organizations, all show that we are rapidly approaching a period when fireproofing will be the rule instead of the exception, and when our present enormous annual fire losses will be reduced to a reasonable amount.

¶ It is with the idea of furthering this great cause of Fire Prevention, and of bringing to the attention of the general public the true function of Fire Insurance, its relation to Fire Prevention, and the methods which are used, that this work has been published. The literature on the subject, particularly along non-technical lines, has been very meager and it is hoped that this Cyclopedia will satisfy a long-felt want.

¶ The appreciation of the publishers is here expressed to the authors and collaborators—engineers, architects, underwriters, practical insurance men of wide experience, and teachers of recognized ability—for their counsel and guidance in the preparation of this work.

FIRE BOAT TEST, NEW YORK CITY

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FIRE INSURANCE INSPECTION

PART I

REPORTS AND THEIR PREPARATION

WRITTEN REPORTS

Necessity for Reports. If underwriting were confined to the locality in which a risk were situated, the need for insurance reports would vanish at once, but owing to the extent of the operations of the Fire Insurance Companies and the number of processes through which a risk must go before it becomes properly insured, some accurate description of the property is necessary. The *underwriter* and the *rater* are unable to give the risks which they are considering a personal examination and yet, in order to render an intelligent opinion, they must become familiar with certain physical and moral conditions of the properties. This information must be furnished them by the *surveyors* and *inspectors*, who, therefore, become the eyes, and to a certain extent the brains of the underwriter and the rater.

The transfer of the information gleaned by the man who has seen the property to the man who is supposed to pass upon its desirability as a risk, becomes a matter of vital importance. Verbal reports, although possessing the advantage of direct contact between the men engaged in judging the merits of the risk, have the decided disadvantage of depending for their accuracy upon the memory, and of leaving no dependable record concerning the risk which has been inspected.

Written reports on the other hand, place in permanent form for the consideration of the underwriter, for duplication, and for filing, accurate data concerning every risk inspected and fall short of being ideal only in so far as the inspector fails to express clearly in words the observations taken. Surveying and inspecting are, therefore, not only a science of observation, but an art of descrip-

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tion, and both requirements should be developed if one would make his work of the highest efficiency.

The description of a fire insurance risk is, in the strict sense of the word, a *survey*, an "over-view," and when properly performed, is as complete and thorough as a physician's history of a medical case, or a lawyer's brief of a legal case. It is a complete story of the risk, including its past history, its present status, and its possible future condition; it should do more than ascertain existing conditions for it should supply the basis for improvements, should anticipate fire and foretell its probable results. Every survey is likely to result in a special problem because of unforeseen conditions. Of six surveyors who examine an important risk, there is probably one man whose perceptions are keenest on this particular risk or who has an *insurance sense* so to speak. As a result, he masters the riddle of this particular conglomeration of hazards and offers the proper solution.

Changeableness is a prominent feature of risks, so surveyors are warned against making a routine of their work. They must keep their methods flexible enough to meet new conditions as they arise; the eye and mind must make their observations without any preconceived notion of what the condition should be, allowing experience to act as a guide, not as a master.

Essentials of a Good Report. A good report does not necessarily follow as the result of a good inspection. An inspection of a risk is a matter of observation of details on the part of the surveyor, coupled with a broad knowledge of the requirements of a good risk and a keen perception of the deficiencies in the proposition under consideration. A report, on the other hand, must convey in words all of the impressions of the inspector regarding the risk—a sort of word picture from which the rater or underwriter can read the good or bad features and draw his final conclusion as accurately as if he had visited the risk himself.

Clearness and Brevity. The language of the report should be direct and well worked out so as to bring the rater in touch with the risk with the least expenditure of time and effort. Again, the statements should be as brief as is compatible with clear descriptions of conditions. Reports should always be reread by the surveyor in order to apply the final test, viz, that the report be clear to the one who wrote it. If the author will stop and read over the report from the viewpoint of a stranger to the risk, he will be surprised at the number of statements which, on second reading, take on meanings quite different from those he really wished to express.

Completeness. A good report should contain all the facts and information that the surveyor has gathered. The bad practice of leaving out certain details which the inspector intends to explain orally, or of leaving out what to him seem trivial matters, should be carefully avoided. If the report is made *complete* it becomes a matter of record, and all subsequent questions relative to the risk will in no way depend upon the memory of the surveyor, but will be answered immediately by the report itself.

Logical Order. A good report will present the various features of the risk in regular order, grouping those which are related to each other and giving each the necessary treatment.

Co-Operation. A good report should be co-operative, in that it should conform, as far as practicable, to the plan or method of work of the person who must make use of the report, if at the same time this does not hamper the inspector and prevent him from describing things as he sees them.

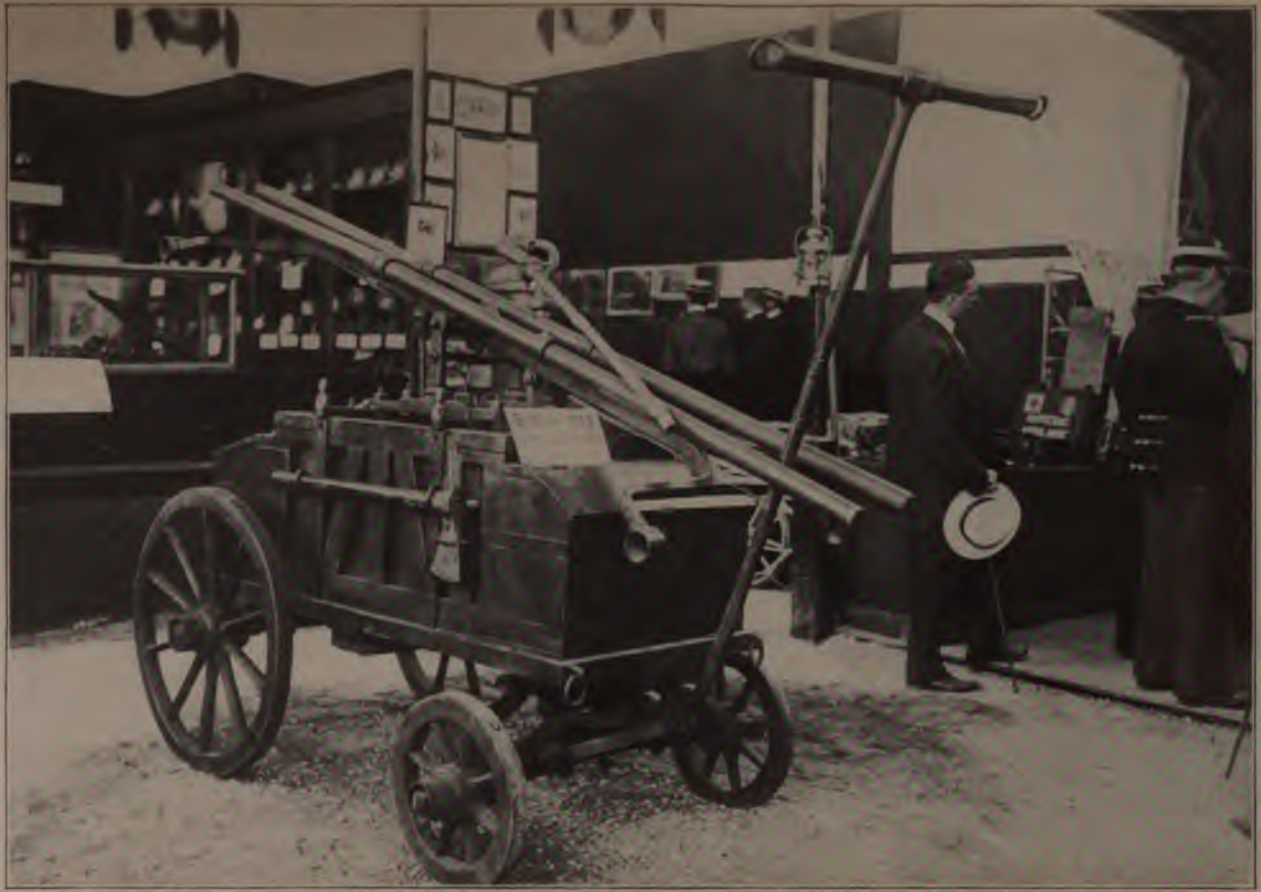
Form of Record. In making reports the use of a permanent notebook is strongly advised, as such a record form is better than loose sheets or temporary memorandums for a number of reasons. *First,* it is a permanent record and can always be referred to in case the report is questioned; *second,* it is an aid to regular practices and uniform methods, because the inspector has the book always with him and can refer back for style and form to the notes taken on other risks. It also develops the habit of making more complete notes than would be made were loose sheets used, and making them while the observations and impressions are fresh and vivid. It takes very little experience for an inspector to find out how quickly he can lose many an important detail if he does not promptly jot it down.

Composition. *Outline.* In writing a report, the ease of composition and the clearness of the result will be greatly increased by the aid of a definite outline or scheme, which consists of the main divisions of the report and a list of the topics in the order in which they are to be considered. As soon as the outline is decided upon by the inspector, he must arrange his material to fit the scheme. He has before him in his notebook a mass of notes, statements, figures, abbreviations, and other miscellaneous information, jotted down more or less hurriedly as he made his inspection. Using this outline as a guide, he can rapidly gather these scattered bits of information into groups under each one of the outline headings, after which each may be worked out to its logical conclusion.

Headings. The headings which appear in the outline can be used to good advantage in the text of the report itself, serving the purpose of an index and acting as so many sign boards to guide the underwriter or the rater to the particular bit of information desired. These headings will appear as follows: centered or main headings; side headings with all capital letters, or doubly underscored; and side headings singly underscored; the importance of the headings being in the order named. To further accentuate certain divisions, paragraphs may be indented—set in a bit from the margin—or material may be put in tabular form, or letters and numerals may be used as paragraph marks.

Report Forms. In the United States there are about forty organizations performing field work requiring the preparation of written reports by surveyors and inspectors. These reports are for use in schedule rating, for general survey, for bureau or exchange information, for the information of the companies, and for reference purposes either by being placed in office files or by being printed and distributed to interested parties. The risks described cover mills, factories, mercantile buildings, hotels, theaters, and omnibus occupancy, either singly or in groups. A careful examination and study of the report blanks of these various organizations will help the surveyor or inspector in his work, and for this reason a brief description of some of the standard forms is here given.

Although the organizations are doing similar work, their reports show considerable variation. For instance, the color of the reports may be white, blue, yellow, or pink; the size may vary from a booklet of 16 pages, 8¾ by 11 inches in dimension, to a folder of 2 pages, 4 by 8½ inches; the ruling on the page, if any, may be anything from ⅛ inch to $\frac{3}{16}$ inch; as to form, the sheet may be flat, or folded with the customary book fold from side to side, or with the legal fold from top to bottom. Some of the reports are typewritten and some



AN OLD FRENCH FIRE PUMP

This Old Pump, Which Is to Be Found in the Musee Des Pompiers in Paris, Was the First Brass Hand Pump. Built in 1742

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penwritten, although the necessity of writing the items which are invariably present in all reports is avoided by printing the standard features upon the report sheet. This latter point must not be carried too far, however, as it can easily result in an appreciable loss of efficiency, particularly where a survey consists of a hundred or more features.

Report forms may be divided into three classes, viz, *outline*, *categorical*, and *flexible*.

Outline Form. In the order of development the outline form undoubtedly comes first, and consists of a number of printed headings corresponding to the various features of the building to be inspected, as follows: Height and size, roofs, skylights and wellholes, floors, floor supports, ceilings, stairs, elevators, communications, lighting, heating, drying, boilers, steam, fuel, ashes, oils, hands employed, and conditions of premises.

Under each of these headings are ruled a number of blank lines to be filled by the description of that feature. The details, however, and method of treatment are not stated on the report.

Categorical Form. The categorical form is a development of the outline, but in addition to the set headings, it contains under each, some very minute directions. A reproduction of a standard categorical report form is shown on pages 6 and 7. With such an encyclopedic form, it is only necessary to fill in *yes* or *no*, and underscore or check the various items.

Flexible Form. The flexible form dispenses with the printed headings and descriptions except for the first page, which contains the name and address of the organization and a few other constant items, such as the location of the risk, the owner, lessee, etc.

DESCRIPTION OF A RISK

Insured and the Insurable Interest. The name of the insured or occupant of the risk should be obtained correctly and stated in full in order to avoid confusion with similar names; it is important to state whether the insured is an individual, a firm, a company, or a corporation. In many cases business is now carried on under a fictitious name or title, instances of which are the use of a trade mark, the use of a company or corporation title to which the insured is not really entitled, and the use of a business title or *style* as it is

CHART—CATEGORICAL REPORT FORM

Survey of Non-Fireproof Building

Location

RISK OPENINGS IN WALL	Open'gs over exp. if adj	DISTANCE	Height and Const'r	EXPOSURES STREET NUMBER	Openings	Opposite	Kind of Shutters	Blank
Front								
Right								
Rear								
Left								

Walls	Brick	Stone	Ironpost Backed	Iron Backed	Hollow Iron in Row	Wood	Glass	Indep	Party	PARAPET? Height	Coped	Thickness—report ledges or proj's 1	2	3	4	5	6	7	Poor Bricks or Mortar?
Front																			
Right																			
Rear																			
Left																			

Height .... Story, Bast .... Sub Bast .... **Area** .... X .... = ...

Bk. Div. Walls? ....

	Side Accessible	Fire Escape	Mansard	Shutters—Kind and Condition	COMMUNICATIONS? Character	Floors	Open or Protected
Front							
Right							
Rear							
Left							

Fire Doors at communications? (Construction and Condition) ....

....

....

Roof .... **Roof Space?** .... Shaft or openings into same? ....

Skylights? (Monitor, size, thickness, frame) Over openings? ....

Extension .... Main Building ....

Cornice .... Wood continuous with other buildings ....

Cupolas, Dormer windows? .... **Wires?** Location .... **3rd rail** ....

Wood Awnings? .... **Frame Ext.?** (Height, size) ....

Ceiling (wood, cloth, paper?) S. ...... B ...... 1 ...... 2 ...... 3 ...... 4 ...... 5 ...... 6 ...... 7 ......

Side Walls (wood, cloth, paper, furred?) S ...... B ...... 1 ...... 2 ...... 3 ...... 4 ...... 5 ...... 6 ...... 7 ......

Metal Lath and wood or iron stud? ....

Floors .... Fireproof floors Construction? ....

Beams, less than 3×10 inches .... Beams, self releasing? ....

All story posts, girders, beams 12×12 inches? (*describe*) ....

Tin, sheet iron, or waterproof paper between floors? .... Inclined water-proof floors with scuppers? ....

Stone piers, or brick piers, with bond or cap stones? (number, size, supporting what?) ....

Iron Columns, etc. Unprotected Columns (Cast or Wrought), or girders, number, what supporting? ....

Stairways? (Number and how arranged. State if stone or iron. If office or dwellings above grade, does stairway from street communicate with store?) ....

....

....

Elevators? (Number and how arranged. In same opening with stairs or adjoining.) ....

....

....

Note: Give particulars if the following floor openings are adjoining or near elevators or stairways.

Hoist or Hatchways? ....

Wellholes? (size, floors pierced) ....

Light and Vent. Shafts? (floors pierced and arrangement) ....

....

....

Dumb Waiters? (floors pierced and arrangement) ....

Chutes, Belt-holes, etc.? (floors pierced and arrangement) ....

Age.................... **Condition,** Broken floors, windows or plaster exposing lath, etc., etc.? ....

Lighting, Electricity.................... Gas.................... Kerosene.................... Open gas lights in show windows ....

Unsafe swinging brackets or unprotected woodwork or stock exposed? (number, location, and arrangement) ....

Have arc lights tight globes or spark arresters? ....

Heating?.................... Wood or metal cold air box to furnace?.................... Steam pipes safe?....................

Chimney, less than 8 inch thick?.................... For what used?.................... Good condition?....................

Bracketed or from ground?.................... On attic floor beams?.................... Floors under and in front of stoves protected?....................

Stove Pipes.................... Through roof floors, partitions, windows, or wall? How arranged? ....

.... Enter bottom of flue vertically or flue in attic or unused room? ....

Boiler?.................... Used for.................... Location how cut off? .... woodwork.... in. distant

Power?.. Ash Cans?....................

Heat used in Manuf'g?..

Benzine, Rubber Cement, Gasolene, Paints, Oils, Varnish, Turpentine, Alcohol, Ethers, etc.? (quantity? where used and in what kept, note floor here and give full report under occupancy)

....

Dry Rooms? (For what, construction, heating, safely arranged and clean?) ....

....

....

Self-Closing Cans for oily waste, rags, etc.? ....

Drip Pans or oil? ....

Cuttings, Papers, Sweepings, etc. (Disposition and receptacles) ....

Packing Material? (Quantity, where and how kept) ....

Bottom of Shafts used for closet or waste?.................... Sawdust on floor and spittoons?.................... Oily floors?....................

Untidiness? (Also as to yards, under sidewalks, gratings, etc?) ....

Crowded? (Without proper aisles. Too near windows. Stale floors?) ....

Fire Buckets? S......B......1......2......3......4......5......6......7...... Good Condition?.......... Well placed?..........

Watchman?.......... When?.......... Rounds?.......... Clock?.......... Station?.......... Records?..........

Special Building Signal?.. **Chemical** engine on wheels?....................

Automatic Alarm?.. **Burglar Alarm** (partial or throughout?) ....

Automatic Sprinklers?.. Perforated pipes, location and supply? ....

Standpipes, internal? (No., size, location and supply, size, kind, length and condition of hose each floor, attached and with nozzle?) ....

....

....

Standpipes, with external Siamese? (Location, size, outlet each floor and roof?) ....

....

....

Roof Hydrants (No., size, supply, hose, housed) ....

....

Pumps for fire use? (Location, kind, size, supply?) ....

....

....

Fire Dept., adjoining?.......... Opposite?.......... 300 ft.?.......... Distance to Fire boat?.......... Hydrants within 300 ft.?..........

technically named. In all of these cases the *real name* of the insured and the *business* or *fictitious name* should be plainly stated in the report, one or the other being placed in parentheses or brackets.

There are many cases in which the *ownership* of property is not a plain, simple matter, and as fire insurance cannot legally be issued except to a person who has an *interest* in the property, this makes it important to find out where interest in one form or another may exist. Conversely, any person who has an interest or share in the property of another is considered an *owner* and, therefore, may obtain insurance.

A list of such cases of insurable interest may be given as follows: lessee, receiver, executor, trustee, attorney, agent, contractor, manager, and administrator.

Location and Address. In describing the location of risks, especially in a city or town which is laid out in streets or avenues, it is usually very important that the name of the street and the number of the building be stated accurately and in full. A building is located by giving its number and the name of the street on which the building fronts; for example, "125 Jones Street." When the number of a building is not plainly indicated on its front, it may be obtained either by noting the number of the building on either side, or by consulting the regular insurance maps, or the real estate maps prepared by the city government.

Buildings which front on parallel streets should be located by giving the street number of each street, the front address first; if there are side addresses also, the order of statement should be front, left, rear, and right.

NOTE. The side of a building having the principal entrance is usually considered the front, while the other sides are generally obtained in fire insurance practice by facing the front of the building and calling the side on one's left hand the left side, and the other, the right side. In consulting maps and diagrams, this same rule is observed; *i. e.*, the map of a building should be turned so that the observer is situated as if he were facing the actual building in the street.

When the address of a building is given according to the street number on the map without regard to that on the building itself, this fact should be indicated by putting the map number in parenthesis before the street number; for example (Map No.) 646 Brown Avenue. In case the two numbers differ, both numbers should be given, the building number coming first, followed by the map number in parenthesis; for example, 648 (646 Map No.) Brown Avenue.

When the location cannot be obtained from the building or the map, it should be described according to the site or plot of the building, giving the distance from the corner lot line of the nearest cross street or avenue to the nearest lot line of the building. The side of the street on which the building is located should always be given; for example, N. side of 100 St., 60 feet W. of Tenth Avenue.

When the building is on a corner, and the street numbers are not available, the location may be described according to the points of the compass; for example, N. W. Cor., or S. E. Cor. of Jones St. and Brown Ave.

When a risk must have a street number and it cannot be obtained in any other way, it should be estimated or approximated, and the number placed in parenthesis, indicating that it is not an established number.

Numeral streets preceded by North, South, East, or West are to be distinguished by numerals without the use of *th*, *d*, etc., as, for example, 45 E. 4 St., or 107 W. 3 St., or 10 E. 1 St. Numeral streets without any word between the building number and the name of the street should be written in full, as 167 First Street, or 289 Second Street.

The names of numeral avenues should be written in full; for example, 75 Fifth Avenue, *not* 5th Ave.

Floor Location. In describing a risk it is very important that it be made perfectly clear what portion of a building is occupied by the one applying for insurance and consequently some rather definite rules should be laid down. Of course, in the case of risks which are occupied entirely by one tenant, *i. e.*, a single insured, the listing of the different floors is not as important as in the case of *omnibus* or multiple-tenant occupancies. In any case, however, all of the floors occupied by an insured should be explicitly stated so that the rater or underwriter may know exactly what part of the building or premises he is considering.

In describing the occupancy of an omnibus building it is customary to describe each floor separately, starting with the first floor and then proceeding with those higher up in regular order.

In case the basement and sub-basement do not belong to the tenant of the first floor, they should be described first. If a tenant occupies several floors not in consecutive order, it is better to describe the entire premises occupied by this tenant in one group. For example, if a tenant occupied the first, third, and fifth floors, the inspector should describe these three floors before considering the second and fourth floors. The advantage of this method lies in the fact that all of the hazards of this tenant are collected into a single description, thus enabling the rater or underwriter to consider the risk to better advantage.

Where a tenant occupies only a part of a floor, this fact should be carefully noted in the description of his risk.

Owing to lack of uniformity in the construction of buildings, particularly with respect to the height of the first floor above the sidewalk, what constitutes *first-floor occupancy* is very often an important factor in insurance rules and contracts. Experience has shown, therefore, that a competent surveyor, in order to avoid dispute as to which is the first floor and which is the basement, will adopt rules approximately as follows:

(1) *First Floor.* The floor which is on a level with the sidewalk or *grade* should be designated the first floor and all floors should be numbered regularly above the first. In case no floor is on a level with the grade, the floor shall be called *first floor* which is nearest the grade, up or down, as determined by the lesser number of steps to ascend or descend to the floor. The first floor is very often spoken of as the *grade floor.*

(2) *Basement.* No very definite rules can be given for designating the floors below the first floor as several methods are followed, involving the use of the terms *basement* and *cellar.* If either word is used the second floor below grade is called the sub-basement or sub-cellar. The number of floors below grade is seldom greater than four and hence almost all needs would be met by designating the first underground floor as the *basement;* the second, the sub-basement; the third, the cellar; and the fourth the sub-cellar. Perhaps the most logical method, particularly for buildings having more than four underground floors, is to call them basements or cellars and number them first basement, second, third, etc., in the same manner as upper floors.

The following abbreviations in floor descriptions are pretty generally employed; for basement, B; sub-basement, S. B; cellar, C; sub-cellar, S. C. The symbol "-" means "from and including, to and including, and everything between"; for example, B-5 means the occupancy commencing at and including the basement, extending through and including the first, second, third, fourth, and fifth floors, but not extending beyond the ceiling of the fifth floor. The symbol "&" for the word *and*, is used only between the last two of the series of floors designated; for example, B, 2 & 5, or 1, 2, 4 & 5. When the occupancy covers only a part of a floor or floors, the respective floor numbers should be enclosed in parentheses and this preceded by "pt.", the abbreviation for *part;* a few examples will make this clear:

Method of designating three isolated floors, to the exclusion of all others, B, 2 & 5.

Method of designating one isolated and two consecutive floors, B, 2-3.

Method of designating two consecutive floors, B-1.

Method of designating one isolated floor and a consecutive series of floors, B & 2-5.

Method of designating a series of isolated floors, with a consecutive series between, 1, 3, 5-7 & 9.

Method of designating a partial occupancy of the basement, pt. B.

Method of designating a partial occupancy of the basement and an entire occupancy of the first floor, pt.B & 1.

Method of designating a partial occupancy of the basement, of the first, and of the second floors, pt.(B-2).

Occupancy. The use that is made of a building generally determines the occupancy of the risk, and this may be either *business* or *non-business* depending upon whether the building is used for the buying and selling of goods and the manufacture of articles to be sold, or for dwellings and places of amusement, worship, instruction, and asylum. Business buildings are usually subdivided into *mercantile* and *manufacturing* occupancies.

Mercantile Occupancy. In describing the occupancy of a mercantile risk which is supposed to have only a stock of merchandise with little or no manufacturing done on the premises, not only must the nature of the merchandise be clearly stated but also the manner in which the stock is handled, viz, *wholesale, retail, sample stock,* or *storage:* if any combinations of these four methods are used, this should also be clearly stated in the report.

When it comes to the condition of the stock, the report should state whether it is *open* or *closed*. The former classification evidently refers to the condition of the stock in an ordinary store, where the goods may be spread out on counters, tables, and shelves, or hung on hooks and racks, with a portion in unbroken or original packages.

In describing a closed stock the kind of container should be noted, *i. e.*, pasteboard boxes, wooden boxes, tin-lined cases, crates, barrels, bottles, packages, or any container that represents protection.

Some miscellaneous specifications to be noted are as follows: Whether the stock is new or second hand, out of date, shelf-worn, or damaged; whether the stock is kept in fireproof safes or vaults; whether the stock is raised above the floor at least 6 inches on skids, shelves, racks, or counters; whether the stock is in waterproof cases or is covered with tarpaulins at night; whether the stock is a mixed stock and the proportion of each different kind.

If manufacturing is done on the premises in connection with what is supposed to be a strictly mercantile business, the manufacturing operations should be described according to the rules for describing manufacturing occupancy.

Manufacturing Occupancy. In the description of a manufacturing occupancy, there are five principal things to be stated, viz, *hands* or *working people, machinery, manufacturing heat, materials used,* and *special processes.*

(1) In giving the *number of hands,* the maximum and minimum number—that is, the number employed during the busy and dull seasons—should be stated; the number of working people engaged in hazardous processes or in special departments should also be given if this will indicate the size or extent of the special operations.

(2) The *machines* used should be described as to *number, kind,* and *source of motive power,* the latter being distinguished as mechanical—that is, derived from an engine or motor—or as hand power, which includes machines worked by hand or foot. Occasionally, power will be supplied by a horse or mule. If the mechanical power comes from individual electric motors attached to each machine, this fact should be noted.

In the case of all machines an oily condition is to be expected, so that if drip pans are needed to prevent unnecessary distribution of oil the fact should be stated, together with a specific reference

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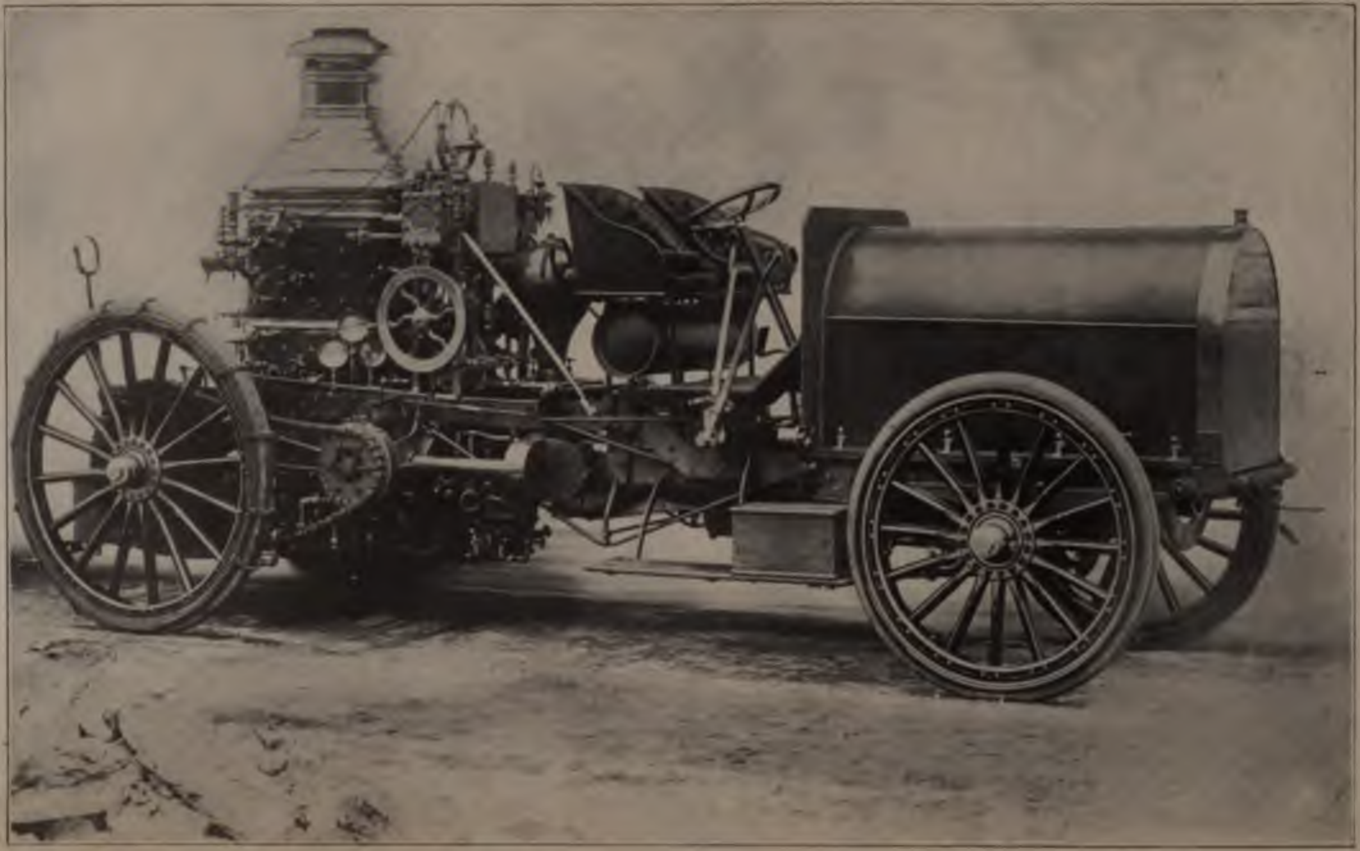

MOTOR-PROPELLED STEAM FIRE ENGINE, NEW YORK CITY FIRE DEPARTMENT to the machines which need the drip pans, and to the fact that the wooden floor, the ceiling, or the wooden partitions are being soaked with oil. In the case of wood-working and other machines which produce shavings, dust, or particles, the presence or absence of blowers or dust collectors should be stated in the report.

(3) *Manufacturing heat*, or fire heat, as it is sometimes called, includes all appliances which produce heat, flame, or fire, exclusive of those which are used for the heating or the lighting of the building. These appliances should be described as to number, what they are used for, the kind of fuel burned, and how each appliance is set up, especially with respect to the protection given to surrounding woodwork or other combustible materials.

If the appliances are of the nature of caul boxes, dry rooms, japanning ovens, or similar boxes or enclosures for baking, hot-air drying, or steaming, their number and size should be given, just as with other appliances. The report should particularly make clear the material of which the appliances are built; the mode of construction such as the supports or framing, the covering laid upon the framing, and whether the covering is of lock jointed tin; the method of heating the boxes or enclosed rooms; whether steam pipes are found in contact with wood, or smoke pipes are close to or in contact with wood; and the method of carrying off the heated air—that is, the ventilation of the boxes by running smoke pipes or vents.

(4) The *materials* used in a manufacturing occupancy should be carefully described, because when they are dangerous, fire-making substances, they are sometimes more important than the machinery or other parts of the plant. They consist of the raw stock, which is the basis of the manufactured article, and the liquids or substances which are kept with the raw material or are used in treating it. When the materials used consist of dangerous substances, the description of them should follow these general lines:

> (a) The supply of the material, that is, the amount kept on hand in excess of that actually being worked; the place where the supply is kept; and the container or method of keeping the supply—if the supply is kept in a special room or vault, this should be described with respect to its location, method of construction, the materials used in construction, and the door arrangements for cutting off the room.

(b) The amount of material in actual use; the kind and size of vessel or can from which it is taken; whether this vessel is a safety can and a description of any defect, if the can is not in proper working order.

(c) The method of using the material; for instance, if it is a volatile liquid, whether it is used by dipping, brush work, or in open vessels.

(d) In case there is an exposed gas flame near the place where a dangerous substance is being used, this fact should in noted.

(e) In describing celluloid, the report should note the quantity carried; the amount permitted by the license; the size of the sheets; the place and method of storage; the method of cutting; and the use that is made of the material.

(f) In the case of excelsior, hay, or straw, the amount baled should be stated; also in the case of loose packing material, the amount present on the premises, the manner of keeping or handling it, and whether it is kept in a standard bin or room or in a non-standard bin or room should be given.

(g) Bituminous or soft coal should be described according to the location, the amount of the coal, and how stored or piled.

(5) The *special processes* or hazards of a manufacturing occupancy, particularly those dealing with highly volatile or expensive liquids or substances, should be carefully described with reference to the nature, the degree, and the extent of the hazard; the method of use or operation; and the place where the operation is carried on, particularly with reference to whether this is in an enclosed or cut-off room or floor, or whether in the open premises. The number of hands working the process is also important, as well as the materials, their quantities stored or used, and the appliances, machines, or utensils which are a part of the operations.

Faults of Management. In describing the faults of management of a risk, the plan is to include in the report all items or features which will show whether the risk is under management which tends to prevent fires, or under indifferent management which will induce fires. In this report the items referring to the building proper should be carefully distinguished from those referring to the tenants. Further it would be manifestly unfair to report unfavorably certain conditions which are a necessary part of a given business and are, therefore, not a *fault*. After stating the faults of management of each tenant it is good practice to collect the various features in a summary at the end of the report.

Considerable latitude must be given as to what a fault of management may be, the construction differing considerably in different territories and with different companies or associations. In order that the student or the inspector may have a nucleus on which to build, the following list of the most common faults is given:

Broken plaster, exposing wood laths.
Sawdust on floor or in cuspidors.
Oil sprinkling of floors.
Stove pipe holes uncovered.
Broken windows.
Holes in floor or ceiling.
Bottom of floor openings untidy or used as closets, or for storage purposes.
Closets used to store old clothes, oil-soaked rags, oil lamps or other objectionable articles.
Paper ceiling.
Rubbish, particularly in yards, cellars, alleys, basements, vaults and under sidewalk gratings.
Wood boxes, packing cases, and old lumber.
Ashes on floor or in wood boxes or barrels.
Clippings, cuttings, and sweepings on floor, in wood boxes, or barrels.
Oil soaked filings in quantity, cotton waste, oil soaked rags, or any material for wiping, rubbing, polishing, or for other uses which result in absorption of hazardous chemicals, when not kept in standard self-closing waste cans.
Crowded stock; aisles less than 3 feet wide and not leading to windows; stock piled to ceiling; windows blocked with goods, obstructing or preventing entrance of firemen.

Construction. In describing the construction of a building, the building is treated as if it were entirely empty, no attention being paid to the furniture or other goods which may be found therein. The various construction features can be treated in almost any order desired, *i. e.*, in a haphazard fashion, in the order established by the report blanks, or from roof to cellar—as is often done because it happens to be the order in which Fire Insurance inspections are usually conducted.

A more logical method, however, seems to be to follow the order established in erecting the building, viz, *foundations; walls; floor construction; roof; roof features* such as cornices, skylights, etc.;

vertical or *floor openings; heat, light,* and *power;* and finally the *fire protection* features. This order will be followed in this work but before taking up the separate features, two items should be recorded, viz, the *height* and the *area.*

Height. The first step is to state clearly the height of the main building and of any extensions which may have been added, stating the height in two ways, viz, in *stories* and in *feet.*

A horizontal division of a building is called in different parts of the world and in different lines of business a *story,* a *floor,* or a *loft,* and misunderstandings frequently occur, not only because of this variance of names but also because of the confusion in designating the floors, attention to which has already been called under the subject of "floor location." In addition to the several methods of labeling floors previously stated, the method of calling the street floor the grade floor and the one above it the first, might be mentioned. Again there may often be found between two ordinary floors a gallery, sometimes called a *mezzanine,* a *deck floor,* or a *half floor;* such a floor is introduced when one floor is about one and one-half times the height of a regular floor, and really consists of an elevated platform running around the four walls of the building and extending out about one-third the width of a floor. Sometimes it is extended across the end of the building like a stage. These various forms of half-floors are not usually counted as full floors, but a notation is made in the report, calling attention to them in order to prevent any misunderstanding. The underground floors, as well as the attics or garrets, should always be stated in giving the height of a building in stories.

The methods of determining the height of a building in *feet* is subject to some variation but a good rule to follow has been given by the National Board of Fire Underwriters in their Model Building Code.

> The height of a building having a flat roof is measured from the curb level at the center of the front of the building to the top of the highest point of the roof beams; in the case of high-pitched roof, the average of the height of the gable shall be taken as the highest point of the building.

The height of the building in feet should be stated wherever possible.

Area. The area of a building is usually given, not in square feet, but in terms of the horizontal dimensions expressed in linear feet. In case the building has three frontages or dimensions, the usual practice is to give the front dimension first, the longest side second, and the remaining side third; this is not always a good method, especially with buildings shaped like the letters **L**, **T**, or **H**, in which case the dimensions of each section should be given separately. In any event, the dimensions of all additions or extensions should be clearly distinguished from the dimensions of the main building. The *length* of a building is its greatest horizontal dimension, and its width, the next smaller dimension.

Foundations. A description of the foundation of a building would naturally include some description of the nature of the soil on which it rests, wherever such information is obtainable. Regarding the foundations themselves, the description should include the kind of stone; the composition of the mortar used; how the underground floors, if any, and the foundation walls are made waterproof; and the presence or absence of sewer connections and their methods of arrangement.

Piers. Where the foundations include or consist of piers, the description should state the material composing them—that is, brick, stone, or concrete; their dimensions; what members of the superstructure the piers support; the details of the bond stones and cap stones, and whether these stones have any protection against fire.

Walls. As the walls of a building are the principal factor in determining the class of the structure, a description of the walls is in some respects the most important thing in a construction report.

In describing a *wood or frame building,* it is not the usual practice to give details of the walls if they are the customary wood-framed walls covered with boards—what might be called the standard wood wall; only the variations or departures from this standard are specified. For example, if the framing or skeleton of the wood wall is of iron, the wall is described as a wood wall with iron framing; if the wood wall is filled in with brick, it is described as brick-filled or brick-nogged.

In describing an *iron building* it should be stated whether the framing or skeleton of the walls is of iron or wood. Iron buildings are usually covered with corrugated or other form of sheet iron.

In describing *stone buildings*, distinction must be made between a real stone building and one with only a stone front. If the walls are really of brick with a facing or veneering of stone, the walls are considered brick walls with stone fronts. The same distinction applies to iron fronts in connection with brick buildings and the report should state on which side or sides of a building they are; whether they are filled in or backed up with brick or other material, or simply closed with boards; and also if they are continuous with the iron fronts of adjoining buildings.

In describing the *brick walls* of the ordinary brick building, distinction should be made between bearing walls, non-bearing walls, and division or interior walls. In the case of bearing walls, it should be made clear which walls of the building are bearing walls; whether they are independent or party walls; and their thickness by floors. The same is true of non-bearing walls, except that these are rarely found to be part of an adjoining building, so that it is usually unnecessary to state whether they are independent or party walls. In the case of *division* or *interior* walls of a building, the report should give the number of such walls; how they divide or separate the building; a description of each wall, except where they are identical; on which floors each wall exists; how it divides the building; whether it has a parapet; and whether there are openings in the wall, and how they are protected or cut off.

Parapet. The description of a parapet or *fire wall*, as it is sometimes called, should state on which sides of the building it exists; its height, its thickness, and the kind of coping and mortar used.

Stone in Walls. In the case of many brick walls, considerable stone will be found either as facing or as trimming or decoration. A description of this feature, when desirable or necessary should state on which walls and on which floors the facing stone—generally called *ashler*—is present, the kind of stone composing it, and the thickness of the stone. In the case of stone trimmings in brick walls, which usually consist of window sills, window lintels, or decorative courses or borders, the kind of stone is the only description necessary.

Chimneys. The description of chimneys should include their number, the use made of them, the thickness of the walls, and the lining if any; attention should also be called to any departure from or failure to conform with the building laws which may be in force.

Fireproof or Fire-Resistant Floors. The description of the fire-resistant floors, except where an entire building has the same construction, should specify which floors are of this construction, the width of the span or arch, the type of construction, and the materials used in making the arch. Fire-resistant floor construction has developed to such an extent that certain standard types have become recognized and are known by the names of the manufacturers or construction companies which have been instrumental in their development. The description of these well-known types by name only is usually sufficient. The nature of the floor surface used in this type of construction is a separate detail, but if an air space exists between the fire-resistant construction proper and the floor boards, this fact should be stated, as well as the depth of the air space. If the air space has been practically done away with by filling in, the material composing the filling, and the fact that it has been well or badly done, should be stated.

Filled-in Floors. Filled-in floors are a form of semi-fire-resistant construction found in connection with wood beams, popularly called "deafening"; the space between the wood beams is filled in with blocks, concrete, mineral wool, or some other non-combustible material. The description of such a floor should state where it is to be found, the material used, and the thoroughness with which it has been done.

Flooring. The description of the flooring or floor boards should be given for each story, unless the flooring throughout the building is uniform. The material composing the flooring should be stated; the thickness; whether there is waterproofing or fireproofing under or between the floor boards; what this consists of; whether surface of the flooring is waterproof, and if so, whether the floor is inclined so as to drain the water; and whether there are scuppers or outlets for the water to pass out of the building.

Beams. The description of wood beams should specify by floors —including the roof—the size or dimensions of the beams; the span or length; the spacing on centers, or the distance from beam to beam; the material composing the beams; whether they are bridged or not; and whether they are self-releasing or not.

Steel beams are usually described in connection with the construction of fire-resistant floors, but where it is thought desirable they may be described separately. Steel beams are now so standardized that they may be described according to the formulas of the steel companies. It is usually sufficient to give the weight of the beam in pounds, and the size in inches.

Girders. The description of wood girders is practically the same as of wood beams, with the addition of two features, viz, whether girders which come end to end are tied or jointed together by metal straps and whether girders which enter and rest upon brick walls, rest upon special bearings or templates.

The description of *steel* girders should be kept separate from the description of steel beams, for the latter are usually a part of the floor-construction arch. The girders require a special description, particularly regarding their fireproof protection, and this should be fully described as to the material used and how it is placed upon the girders. One form of protection that should be noted is the *hanging ceiling.*

Columns. The description of wood columns should specify by floors the number of rows, the size, the spacing from column to column, the dimensions of the bays, the material or kind of wood composing the column, its shape, the use of a cap and base plate, and the presence or absence of superimposing or continuous posting.

The description of metal columns should specify whether they are of cast iron, wrought iron, or steel, and whether the columns are in the walls or in the interior of the building. The fireproofing of the columns should be described as to the material used, the method of applying it, and the presence or absence of an air space, and it should be established whether the column protection has been broken into by running pipes between the column proper and the column protection.

Roof. The description of a roof should state any departure from the simplest type, known as the *flat* roof. High-pitched roofs have various names, such as *peaked* roof and *gable* roof. The framing or skeleton of the roof, unless already treated under floor construction, should be described, as well as the materials used for covering the framing—usually boards. In regard to the weather protection or waterproofing of the roof, it should be made clear under which one of the standard types the roof belongs, viz, tar roof, tar and gravel roof, tile roof, slate roof, plastic slate roof, metal roof, or shingle roof.

TYPICAL FIRE SCENE
Water Tower in the Background Not Yet in Action. High Pressure Streams Are Seen in Extreme Rear

If the roof is a *mansard* roof—or floor, as it really is—the report should state on which side of the building it occurs, the kind of framing—wood or iron—and the kind of covering.

All roof structures should also be described stating number, sizes, and how they are constructed if they differ from the general construction of the building. The term *roof structure* includes cupolas, dormers, towers or steeples, tank houses, and other superstructures of various kinds, which really add to the height of the building by making an additional floor or part of a floor.

References should also be made to the open space between the boarding of the roof and the ceiling of the top floor, usually made as a result of pitching the roof and called *roof space, hanging ceiling, blind attic,* or *cock loft.* The description should include the average height in feet, the amount of space, and particularly whether there is a shaft or opening into it which connects the roof space with the rest of the building.

Cornice. The description of a cornice should state whether it is open or boxed; the material of which it is made; whether the cornice is open to the roof space, or whether it is built entirely outside the front wall—in this latter case it makes no hazard, because it is entirely cut off—and whether it is continuous with the cornices of other buildings and with what building it is so connected.

Skylights. The description of skylights should specify their location, type, frame, glass, and screen.

In giving the location of a skylight, the report should specify whether it is on the main building, on an extension, on an addition, or over a floor opening; in the latter case, the kind of floor opening should be specified.

The types of skylight include the *common flat* skylight and the *raised* skylight with glass in both sides and top; this latter type includes the *box* skylight, the *lantern* skylight, and the *Texas* or *long monitor* skylight. A special type is the *studio* skylight, which is really more like a large window.

It should be specified whether the *frame* of the skylight, into which the panes of glass are set, is wood or metal.

The description of the glass in skylights should specify the thickness, the kind of glass used, and the size of the panes if they are of large dimensions.

A description of the *screen* used in connection with skylight applies only to the screen on the outside of the skylight and should include the gauge number of the wire, the size of the mesh, the distance the screen is raised above the skylight, the distance it extends beyond the width or length of the skylight, and the method of supporting the screen, *i. e.*, how the screen is attached to the brackets or supports and how these supports are attached to the skylight frame.

The description of skylights may be considerably shortened by the use of a fixed order for the items, with certain variations to suit the different frames of skylights. A few examples will show the method, the specification for each item being, in actual practice, put in place of the name of the item.

Common Skylight. Location × number and type × material × size × thickness and kind of glass.

Monitor Skylight. Location × number and type × material × size × thickness and kind of glass on top × thickness and kind of glass on sides (or louvres).

Skylight with Screen. Location, number and type, material, size, thickness and kind of glass; location of screen and frame and how bolted; size of mesh of wire, distance above glass, distance beyond glass on sides.

Partitions. Partitions should be specified by floors unless they are uniform throughout the building. The report should state the framework of the partitions, the width or thickness, the kind of material composing the frame or studding, the kind of lathing, and the material composing it. If the partitions are built of some form of fire-resistant material, the report should specify the size or thickness of the material as well as the method of erecting the partitions, particularly with reference to the use of wood supports or frames.

Finish. The description of the finish of a building should distinguish between the finish on the walls and the finish on the ceiling. If the inside surface of the walls is left untouched, this is called *open finish.* If the brick surface is covered in any way, the report should state the fact, the material used, and the method of attaching it, particularly with respect to an air space between the surface of the brick wall and the surface of the covering, called *furring.* The description should state clearly which walls have furring, and whether the air space is fire-stopped at the different floor levels.

The description of the finish on the ceiling is the same as for the finish on the side walls, except that the question of the air space does not arise unless the ceiling is a *hanging ceiling*, that is, not attached directly to the bottom of the beams or floor construction proper, but suspended some distance below this by means of rods or hangers.

Fire Escapes. The description of the fire escape should cover its use by the fire department as a means of entrance to a building, and as a vantage point from which to fight a fire. The report on a building should state the number and type of fire escapes, on which sides of a building they are, and the floors reached by them.

Floor Openings. The description of floor openings should be *without exception* the most complete and most detailed of any item of construction. The description should give the number of floor openings; their location in the building; the floors to or from which they extend or which they pierce; their uses and forms, such as *shafts, enclosures, doorways, windows,* and other openings in the shaft walls; cut-offs or fire stops in place at these openings; the presence of a bulk-head or other terminus of the shaft at the roof; and any other item or detail that would play a part with fire entering or traveling through the shaft from floor to floor.

The description of the shaft should state whether it is open or enclosed, and if enclosed, details should be given of the manner in which this is done—that is, by walls or partitions built close around the opening or by partitions or walls at some distance from the shaft, making a hall or room. The description of the shaft walls or the enclosing walls should state the materials used and the method of construction. The cut-offs or fire stops at the openings in the shaft enclosures should be described according to the material, the construction, and the method of operation. This usually applies to doors and window frames.

The descriptions just given apply to all floor openings, but in addition each type of floor opening has one or more separate features that should be described. In describing several floor openings of the same type, the best results will be obtained by first stating the number of such floor openings, and then giving a detailed description, giving each a letter to identify the floor opening.

The description of a *stairway* in addition to the general descriptive items of a floor opening should give details of the stairs proper, that is, whether the material of the stairs is wood, stone, or iron; the framing of the stairs; whether the treads are of stone; and whether there are iron plates under the treads and the landings.

The particular description of an *elevator* should include details of the cable opening into the power room, the location of the power, the kind and source of power, the size of the room, and the method of cutting it off from the rest of the floor or the building. If the elevator guides are of wood, this fact should be noted, as well as the presence of wires, cables, or other combustible materials in the shaft way. Elevator doors, particularly the front or entrance doors, in the case of office and residence buildings, are frequently iron doors made after the pattern of a gate and called a *grille* door.

The particular description of *light or ventilating shafts* requires details of the cut-offs at window openings, which are different from the cut-offs in other shafts. Whenever there are fixed shutters or louvres, the report should state the material of the louvres, the method of attaching them to the framework, and the method of attaching this framework to the walls of the shaft, that is, whether soldered or riveted.

The particular description of a hoist, hatchway, or wellhole covers the presence of cut-offs at the floor levels in the form of traps; the descriptions should specify the presence of the traps by floors and the method of operation. If hand-closed, the report should state whether closed nightly; if self-closing, the report should state the material composing the traps, the location of the fusible link, the presence of weight, pulley, and vertical backstop. In case of a wellhole, the area should be given.

The particular description of *belt holes* should give the size of openings, whether the belt holes are boxed or curbed, and the details as to material and arrangement.

The particular description of *floor lights* should describe the frame and state the thickness of the glass.

The particular description of *chutes* should specify the use made of them.

The particular description of channels or chases in walls should specify the presence of fire stops at the floor levels, the material used, and the method of arrangement.

Fire Protection. *Fire Pails.* The description of a fire pail equipment should state the number of pails on each floor, or on each other division of the risk, the material of the pails, their capacity, color, lettering, shape, method of setting, distribution, location, care, and supervision. If sand pails are installed instead of water pails, their number and their location should be given. Precautions against freezing should be noted, as well as the substitution for ordinary pails of patent bucket tanks, casks, or barrels of water and patent fire pails. It should be stated whether the employes or occupants have a knowledge of or practice in the use of pails.

Chemical Extinguishers. The description of chemical extinguishers should state the number of extinguishers by floors or other divisions of a risk, the type of extinguisher, the manufacturer's title, the presence of the Underwriters' Laboratory inspection label, the method of setting, the location and maintenance, including the precautions against freezing. If the employes or occupants have any knowledge of or practice in the use of extinguishers, this should be noted.

Standpipe System. The description of a standpipe system should give the number of standpipes or risers, their diameter, location, the presence of an outside fire department connection, whether there is such a connection to each riser, whether the different risers are cross-connected and where. The details of the fire department Siamese connection should include the size of the coupling, the setting of the Siamese, the presence of check valves in it, the dimensions of the feed line from the Siamese connection to the riser, as well as the presence of a drip or tap valve and a check valve pointed against the direction of flow from the riser.

If the standpipe system is a wet system, the source of water supply should be described. If the source is a tank, the report should state its location; whether it is a gravity or a pressure tank; its construction, its capacity, and the material of which it is made. The distance from the bottom of the tank to the highest hose connection—excepting a roof connection—should be given, together with the diameter of the horizontal feed line from the tank to the riser, the presence of a gate valve, and a check valve properly pointed against the riser.

The description of the tank should further state the presence of an indicator or tell-tale to measure the contents, whether the tank is filled by a separate filling line or by the use of the riser, and whether the tank is used exclusively for fire purposes, or also for domestic purposes. If the standpipe system is supplied by a pump, the details of the pump should be given.

The hose connected to the standpipe should be described by floors, specifying the number of hose connections, the length of hose, kind and manufacturer's brand; the play pipe or nozzle that is attached, the size of it and the presence of wrenches should also be stated.

The construction and installation of the piping should be described with respect to the pipe material, the method of suspending or supporting it, the character of the fittings, and the running of the lines.

Perforated Pipe Sprinklers. The description of perforated pipe sprinklers should state on what floors or parts of the premises they are installed; what sections of the building each separate equipment covers; the material and diameter of the pipes; the size, spacing, and distribution of the holes or perforators; whether the holes are punched or drilled; the method of hanging the pipes; and the spacing or number of runs of piping. The dimensions of the feed pipe and the fire department connection should be stated the same as for the standpipe system.

Watchman and Clock. There are three systems of inspection by watchman and clock in use, and the items which should be included in the description of each are given as follows:

(1) The description of the *central-office* or *central-station* system should include the building containing the office, the instruments for receiving and recording the signals, the arrangements for transmitting these signals to the fire department, the operation of the instruments with reference to the interference of signals and the registering of trouble signals, the material of the circuits, the method of providing a return circuit, the number of boxes on a circuit, and the number of watchmen reporting on a single circuit. The signals in use should be described with respect to the difference between ordinary watch signals and fire signals; the watch boxes and their mechanism should be described with respect to standard specifications.

(2) *Local* or *private stationary* systems should be described by giving the time of rewinding the clock, the method of observing the record dials and of making the record when the clock is opened. The mechanism used at the stations for operating the clock should be described, and if there are magnetos, details should be given.

(3) The *portable watch clocks* should be described by giving the time for rewinding, the mounting, the casing, and the method of protecting the record dial against tampering. The manner of making the records on the paper and their legibility in each case should be stated.

For all systems the following features should be included in a report or description: The time of service; the patrol periods; the number and location of the stations; the wiring; the keeping of the records; the lantern used by the watchman; the oil burned by the lantern; and the supervision of the performance of duty by the watchman.

Automatic Sprinkling Equipment. The description of an automatic sprinkler equipment should cover the following items: *mechanical equipment, water supply, alarm service, fire control, maintenance*, and *non-protection*.

Mechanical Equipment. The description of mechanical equipment should include the following details:

(1) The *piping* covers the number, size, and location of feed lines or risers; the spacing and sizes of the piping in the distribution lines from the supply risers; and the methods of the installation in hanging or supporting the pipes.

(2) The *heads* or sprinklers proper cover the type, the number on the various pipes, the position of the sprinklers, and their condition.

(3) The *valves and fittings* cover the type of valves used at the connections to water supply, the location of the various valves, and the protection to valves or the precautions taken to insure their operation.

Water Supply. The description of the water supply for the sprinkler equipment should mention the *sources* of supply; their number and whether they are independent; the capacity of the supply; and the existing *pressures* in the systems. The different types of source of supply should be described as follows:

(1) If a *public water works system*, the static pressure at the highest line of sprinklers, the size of the mains, and the presence of a meter or pressure-regulating valve should be given.

(2) If a *pressure tank*, the number of tanks, the capacity of each, the location, the use of the supply from the tank, the proportion of water, the air pressure maintained, the presence of gauges, the arrangement for filling the tank, the type of air compressor used, the provision for draining the tank, and the construction and supports of the tank should be stated.

(3) If a *gravity tank*, the number of tanks and their capacity, the location, the elevation of the bottom of the tank, the kind of hoops and the material used in their construction, the arrangement for filling the tank, the use of the water as a supply, and the presence of an indicator, overflow, and independent drain should be stated. In addition, the connection of the discharge pipe from the tank to the sprinkler system and the precautions taken against the water freezing should be described.

(4) If a pump, the description should include the kind of pump, its capacity and location, the suction and water supply, and the source of power.

(5) If a *steamer connection* for fire department engines, the description should give the number of these connections, whether single or double (Siamese) couplings, whether threads of couplings fit fire department couplings, the presence of a proper sign, proper valves in the feed line, and proper arrangements for draining.

Alarm Service. The description of the alarm service should include details of the method by which the flowing of water is announced, the method by which high and low water levels are under observation, and the automatic supervision by electrical attachments.

The description of the *water flow alarm* should include the alarm valve used for this purpose, and whether it operates an electrical gong, a mechanical gong, or both; it should also state the location of these gongs and their connection with the fire department or with a central-station alarm office.

The description of the *high and low water signals* should state the arrangements for giving these signals and the bells operated, or the place where the alarms are sent. The use of non-approved alarm valves in the system should be noted.

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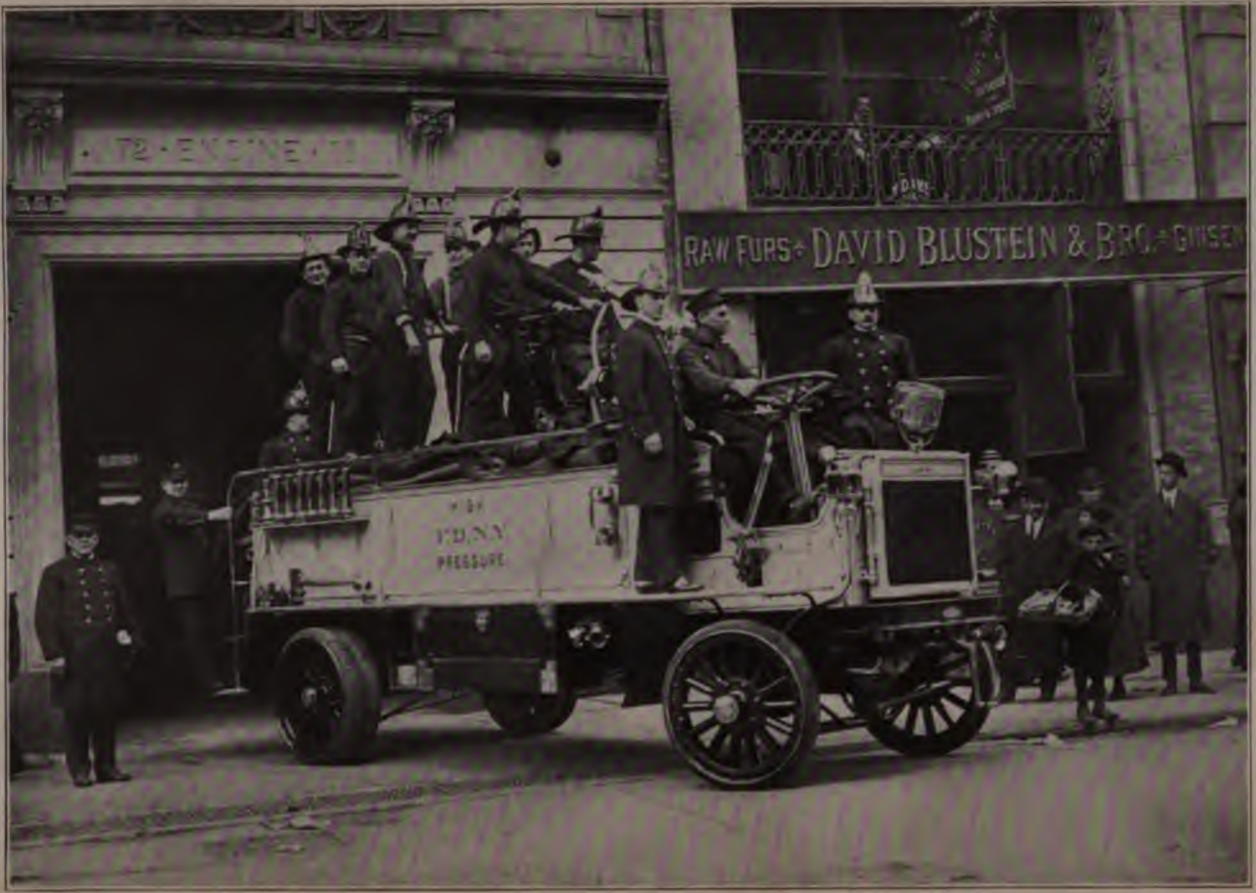
ASTOR, LENOX AND
TILDEN FOUNDATIONS.



IMMENSE MOTOR-DRIVEN HIGH PRESSURE HOSE WAGON, NEW YORK CITY FIRE DEPARTMENT
On Account of the High Speed Possible These Wagons Can Be on the Ground Very Promptly. They Carry an Immense Amount of Hose and a Big Crew

The description of the *automatic supervision* should note the attachment to the gate valves in all parts of the system, the pressure sources, the water levels, the temperatures of water supplies which might freeze, the flowing of water, and the leaking of water. The description of the alarm system should also include reference to the facilities for giving manual fire alarms, and the presence or absence of a watchman.

Fire Control. The description of fire control should cover all possibilities of the automatic sprinklers being unable to extinguish or control a fire, such as conditions of unusual area of rooms, contents likely to prevent complete sprinkler distribution, premises with unusual draft conditions, occupancies representing flash-fire hazards or quick hot fires not readily extinguished by water, explosion hazards, and dangerous vapors. There should also be specified any fixed obstructions to water distribution, the absence of sufficient clear space, a large percentage of the equipment on a "dry" system, and a large percentage of the sprinkler heads being "extra high test solder," the presence of unstopped vertical openings in the building, and the presence or absence of approved curtain boards.

Maintenance. The description of the maintenance of an automatic sprinkler system should cover the measures that are taken to keep the equipment in good condition as distinguished from those precautions which are taken to insure the operation of the sprinklers in case of fire, reference to which has been made under the subject of *alarm service.* The system of inspection provided for should be noted as well as mention of the competency of the person making the inspection, and whether a proper report is rendered by him to a person in authority. The description of the inspection system should note whether such inspection includes a supervision of matters likely to impair the physical condition of the equipment, unauthorized alterations, changes in the occupancy, examination of valves, spoiling of sprinkler heads, and condition of water supplies.

Non-Protection. The non-protection item of an automatic sprinkler system should describe the features that are not included under sprinkler protection, such as unsprinkled sections of the building, small enclosures, large areas, and parts of the equipment shut off during cold weather.

Fire-Alarm Systems. *With Central Station.* The description of fire-alarm systems in general should include the following items: *Central office* or *operating room*, *wiring*, *circuits*, *instruments*, *installations*, and *operations*. In the case of particular types of fire alarms, their special features should be described after the general features common to all systems have been stated.

The description of the *central-station office*, or *operating room* of a fire-alarm system should state the force employed, the presence or absence of plans of the outside lines, the physical conditions of the building from a fire standpoint, the instruments in use, and the system of making tests.

The description of the *wiring* should distinguish between underground wires and aërial wires; if aërial wires are used, the presence of heavy current protectors at the building, the size of wire, metal, insulation, and method of support and of running should be noted. In the case of wires inside of the building, the wire used should be described, the method of running it, the protection against injury or contact with other conductors, and the physical condition and workmanship of the installation.

The description of the *circuits* should state the use of metallic circuits or earth-return circuits, underground or aërial, and the number of equipments or boxes on the circuits.

The description of the *instruments* should include the arrangements for receiving, recording, and transmitting signals; the arrangements for registering trouble signals; the construction and setting of the instruments as precautions against jarring or derangement of parts which would prevent the mechanism from operating; and the location and encasing of the instruments.

The description of the *installations* should give the number of boxes, their location, distribution, setting, and places of transmission of signals.

The description of the *operation* should state where the alarms are transmitted and re-transmitted, the manner of making tests, and the arrangements for competent inspection.

Automatic-Alarm System without Central Station. The particular description of this type of alarm system should specify the arrangements tending to prevent a break in the wires inside the building which would prevent a fire alarm being sent, or to prevent a break outside the building disabling more than one connection to a receiving point. The description should further specify what arrangements are used, when a break in the wires occurs, to give an alarm which shall be quite distinct from the fire alarm, and the place where this trouble signal is received. The kind of bells used at the risk, the gongs used at the receiving points, the location and enclosure of transmitters, relays, and annunciators, the testing apparatus used, and the arrangements for making tests should also be detailed.

Automatic Journal Alarm. The particular description of automatic journal alarms should state the subdivisions of the circuits, the presence of *finding switches*, their location and the wiring necessary to permit cutting out; the location of thermostats on bearings; the temperature setting of the thermostats with a proper index, and the use of the independent relays for each circuit. The bell equipment should be described, particularly with reference to short-circuit bells at the annunciator, the sets of finding switches, and a system of bells to announce circuit numbers on each floor of the building.

Thermostat System. The particular description of thermostats should include their installation in all parts of the premises; the running of the lines next to walls, partitions, under pitched roofs, hatch closets, and shaft openings; the spacing under different types of ceilings and the method of support.

Heat, Light, and Power. The description of heat, light, and power as found in any risk should distinguish between that which is used as a part of the building or building service, and that which is used on the separate floors in the premises of individual tenants. The description should compare the installation under consideration with approved installations, showing the departures from or violations of the approved systems as laid down by the municipal ordinances, such as the building code, or as laid down by the insurance organizations. The following suggestions for describing heat, light, and power are, therefore, general in their nature and are designed to give only the essential features, leaving particular descriptions to conform to the necessities or desires of the organization using the reports.

Heat. The description of the heat of a building should specify the kind or source, the location of the appliance, its enclosure or lack of enclosure, the materials and form of construction of this enclosure, the openings in the enclosure, and the cut-offs or fire stops put in place.

For *steam heat* coming from a boiler in the building, the kind of boiler, *i. e.*, the manufacturer's description and the horse-power, should be given. The foundation of the boiler should be described, particularly with reference to the combustible construction of the supports or the setting. This applies not only to the actual space taken up by the boiler and its setting, which latter is usually of brick, but also the surrounding space on all sides. The foundation of the ash pan when this extends beyond the boiler proper should also be described. The presence of combustible construction within a distance of 3 feet or less on all sides of the boiler should be noted, as well as the protective covering, if any, which is in place.

The description of the *stack*, should state the material used, the construction of the stack and its base, its height above the highest point of the roofs of adjoining buildings, the presence of a spark arrester and the size of its mesh, and whether the stack is capped. Where the stack is of metal and passes through a combustible roof, the clearance, or distance from the stack to the woodwork, should be noted.

Regarding the *flues*, the thickness of the walls of a brick flue should be stated; also whether fire brick and fire mortar were used on the inside walls of the boiler flue at the section close to the source of heat. In the case of flues leading from apparatus which would heat the flues to a high temperature, the use of double walls with an air space between them, and the use of an inside wall of fire brick should be noted. In describing smoke flues it should be stated how high above the roof they extend, whether they are lined with some material such as cast iron or terra cotta clay, and whether this lining is smooth and well fitted.

The description of *steam pipes* should make note of any place where the piping is within 2 inches or less of timbers or woodwork, and also whether there is a shield or protection within a distance of an inch or less. Where steam pipes pass through the floor construction or partitions, the protection should be described, particularly with reference to the use of a metal tube or sleeve and metal cap at the floor level. In the case of pipes running vertically and horizontally the presence of a metal shield over, and on the sides of, the pipes should be described. Where pipes are run in wood boxes, in casings, in chimneys, or in recesses which have wood covers, the protection of these wooden parts with metal should be noted. Where steam pipes are covered with some material, it should be noted whether this covering is incombustible, fireproof.

The description of a *furnace for hot-air heating* should follow the same general plan outlined for a boiler. The particular points to be noted in the description of a hot-air furnace are the material used for the cold-air box, and the construction and installation of the flues or ducts for carrying the hot air. The enclosing walls and the linings for stone or brick hot-air flues should be described; where they pass through floor construction or lath-and-plaster partitions, the presence of single piping or double piping should be noted as well as the method of keeping an air space between the metal of the pipe and the woodwork, and the shielding or covering of the woodwork. The distance from the furnace of a vertical hot-air pipe, which enters combustible construction in a horizontal direction, should be stated; also the presence of double piping wherever hot-air pipes are run in closets. The distance of hot-air pipes below floor beams or ceilings should be noted when this distance is 6 inches or less, except where there is a metal protection, in which case the distance is 3 inches or less. Register boxes should be described with reference to the material composing them, the material composing the frame or border, the clear space on all sides of the register box, and the presence of a metal casing in this clear space. Where registers are located over a brick furnace the method and the materials used in supporting the register from the top of the furnace should be described.

The description of a *coal stove* should include the foundation or setting of the stove, the passage of the smoke pipe from the stove to the flue or chimney opening, and the closeness of the stove and the pipe to combustible materials. The description of stoves that are supported on legs should state what kind of a floor is underneath, and if it is a wood floor, what protection is provided for the woodwork. Stoves that are not set on legs but rest flat on the floor should be described particularly with reference to the use of foundations of brickwork and sheet iron as a substitute for wood beams and wood floors; the presence of a metal shield in front of the ash pan should also be noted. The side and top clearance of the stove from combustible construction and the use of metal as a shield should be given, and in the latter case, the distance that the metal extends beyond the actual space covered by the stove should also be stated. The contact or nearness of smoke pipes to combustible construction, and the presence of metal shields for protection should be noted.

Light. The description of the lighting system of a building should specify the kind of light, the source or main supply, and the necessary details concerning the appliances or machines by which the light is used.

The description of a *gas-lighting system* in a building should state the kind of gas, where it is manufactured, and how it is supplied to the risk, the supply or feed main, its location and size, the kind of meter and the shut-off; the size and arrangement of the distribution system from the meter should also be given. The kind of branches or brackets in use should be stated (particularly with reference to their distance from combustible construction) whether they are a swinging or folding type, and if so, their contact with combustible materials. The burners or jets should be described particularly with reference to their distance beneath combustible materials with or without protection; also their presence in store windows and at work tables with or without globes or cages. When gas jets are enclosed in lanterns the type of lantern and the manufacturer's description should be given.

The use of *kerosene oil for lighting* in places other than dwellings should be stated, and if its use is extensive, the number of lamps, the quantity of oil as a supply, and the means of keeping it should be given. Kerosene oil used under pressure to supply kerosene vapor lamps, stoves, blow-torches, and furnaces is much more hazardous than when used in ordinary kerosene lamps or stoves; the description of these systems should follow the National Board of Underwriters' rules covering oil supply tanks, distributing tubes, and appliances.

The use of *gasoline for heat, light, and power* should follow the National Board of Underwriters' rules covering gasoline engines, gasoline stoves, and gasoline vapor gas lighting machines, lamps and systems.

The use of *acetylene for lighting* should follow the National Board of Underwriters' rules covering permitted machines, the installation and use of generators, the storage of calcium carbide, and the use of portable lamps.

Power. The description of power should state the kind, *i. e.*, hand, pedal, animal, or mechanical, the latter being subdivided into steam, gas, and electric.

Steam power should be described with respect to the location of the engine, the size, make, and capacity; its setting; whether open or enclosed, and if enclosed, the construction, material, openings, and protection or cut-offs.

A *gas engine* should be described as regards its location, size, make, and capacity; its setting; whether open or enclosed; and the method of ignition. The description of the setting should state whether the foundation is wood, metal clad wood, stone, or brick. The enclosure, if the engine is enclosed, should be described as to its construction, material, openings, and the protection or cut-offs. The description should further give the method of ignition, *i. e.*, whether flame, hot tube, or electric; and the position of the gas bags relative to gas lights, and the distance in a horizontal direction of the bags from the gas lights or the hot tube. The exhaust chamber should be described with respect to its setting above wood floors or combustible materials; the exhaust pipes should also be described relative to their clearance and protection from woodwork, the method of running the pipes through floor, partition, or wall construction, and the shielding or protection with metal sleeves or fireproof covering. If the exhaust pipes enter chimney flues, it should be stated whether they extend out and above the top of the chimney.

Electrical Conditions. The description of electrical conditions of buildings or premises varies considerably, according to whether the electrical current is generated on the premises, or is received from an outside source. In the latter case, the description is simplified because of the absence of the generating or manufacturing electrical machinery. When electricity is generated on the premises, the plant is usually spoken of as an isolated plant and its description will involve the usual features, beginning with the generator.

Generators. The description of a generator should give the number, the type or manufacturer's title, the capacity in volts and amperes, and the normal speed—which information is usually stated on a name-plate attached to the generator.

The location of the generators should be stated, particularly with reference to dryness, protection against accidental moisture, safety from gases or flying particles of combustible material, and proper enclosure from a fire protection standpoint.

The setting of the generators should be described, particularly with reference to the frame of the generator being insulated from the ground.

The protection of the generators against overloading should be stated by describing fuses or circuit breakers, and their suitability for the purpose.

The provision of a waterproof cover, a receptacle for oily waste, and the use of a competent dynamo tender should also be noted.

Switchboard. The switchboard should be described with reference to the manner in which it is set up, the danger of communicating fire to combustible material, the freedom from moisture, the material composing the switchboard, and the accessibility of the wiring. The equipment of the switchboard, *i. e.*, the instruments, their mounting, and installation should also be described.

Rheostats. The description of rheostats should show whether they are mounted on a switchboard, or, if not, whether they are placed at a proper distance from combustible material or properly separated therefrom.

Conductors. The description of the conductors should include the kind of wire, whether it is of ample or insufficient carrying capacity, the kind of insulation, the supports, the method of running the wires through construction work, and the method of enclosing the wires. Any special installation features should be mentioned, particularly the protection against mechanical injury on side walls, contact with pipes and other grounded metal work, exposure to moisture, the presence of splices which are unsoldered or improperly taped, and the use of cord wire for line work.

In the case of outside wires, the description should include the absence of bushings and drip loops, the method of carrying the wires, the supporting of the fixtures, and the clearance of roofs or grounded metal work. The absence of lightning arresters should be noted and where these are installed, their accessibility and separation from combustible material and their proper grounding by attachment to gas pipes.

Cut-Outs. The description of cut-outs should state the make, whether properly arranged, whether exposed to inflammable materials, gases, dust, or combustible floating particles, and if so, whether in approved cabinets, or in dustproof cabinets when in *dust* rooms. If exposed to dampness it should be stated whether the cut-outs are enclosed in a waterproof box or mounted on porcelain knobs.

Switches. The description of switches should state the type and make, whether any are out of order or not properly installed, and whether they are too small, or are exposed to inflammable materials, vapors, etc.

Incandescent Lamps. The description of the lamp equipment should state in general whether the lamps are fitted with inflammable shades; whether they are exposed to inflammable materials, corrosive vapors, flyings, and moisture, or whether they are without necessary mechanical protection.

Lamps on fixtures should be described with regard to proper construction of the wiring and the insulation from grounded metal piping.

Incandescent lamps on pendants should be described with reference to twisted wire or unapproved cord, and the bearing of the cord. It should also be made clear whether they are supported from defective rosettes, whether they are hung on nails, or whether the cord is too long. It should be stated if the lamps are not equipped with proper wire guards or if the sockets are defective or unbushed.

Portable incandescent lamps should be described with respect to being equipped with standard pendant cord, whether they are provided with wire guards, the use of unapproved attachments, and the necessity for repairs.

Arc lamps. Arc lamps should be described with respect to being enclosed or not guarded and not provided with individual fuse protection.

Nernst Lamps. Nernst lamps should be described with regard to exposure, to mechanical injury, the lack of protection by suitable fuses, and the general inspection given them.

Mercury-Vapor Lamps. Mercury-vapor lamps should be described with respect to proper protection by fuses, the installation of resistances, and the proper casing or installation.

Motors. The description of the motors should include the number, type or manufacturer's trade name, the capacity in volts and amperes, and the normal speed, which information is usually stated on a name plate attached to the motor.

The location of the motors should be stated, particularly with reference to exposure to dust, vapors, and inflammable materials.

The setting of the motors should be described with respect to the insulation from the ground and the filling of the base frames and wood floors to prevent the absorption of moisture.

The wiring for the motor should be described, particularly with respect to the capacity of the motor leads or branch circuits and whether the circuit is overfused. The presence of a cut-out and switch, the location of the switch and rheostats, the use of rheostats, the protection of rheostats and autostarters, their location in wet, dusty, or linty places, the use of a waterproof cover and the enclosure in an approved case should also be stated.

Special Hazards. The term *special hazard* is applied to certain risks of a producing or manufacturing character, which are considered especially dangerous or liable to frequent and destructive fires. The same term is also used to describe the danger-producing features of ordinary risks or manufacturing risks of which the business, as a whole, is not considered especially dangerous.

The description of a special hazard should give complete information regarding the degree and the extent of the hazard. Such hazards may be classified as *furnaces, dryers, kettles,* and *volatile* or *explosive substances.*

Furnaces. The description of furnaces should give details of the stack or chimney, its setting, its clearance, and the method of heating, *i.e.*, the fuel used. The description of the setting should cover the nature of the enclosing walls of the furnace and the manner in which these, as forming the furnace, are set or arranged, as well as the condition in which they are found. The description of the clearance should cover the distances of any heated portions of the furnace from woodwork or other fixtures of inflammable material. This is not meant to include the distance to or proximity of temporary rubbish or other materials, which is a fault of management. Clearance refers to any one or all four sides and overhead.

The description of the stack or chimney—by which is meant the enclosure for the flue which conveys away the heated gases of combustion—should give details of the breaching or up-take or downtake to such stack or chimney. It should treat of the construction of the stack, its location—*i. e.*, whether inside or outside the building or contained in the walls of the building—and the general condition of the chimney. The description of the method of heating or the fuel used should deal with the source of heat and the conditions under which it is handled or used.

Dryers. The description of the dryers as a class should deal principally with their construction and the method of heating. This statement should include the arrangement and in many cases the location of the device. Note should be made in particular of steam pipes, hot-air flues or conductors which are close to or in contact with wood or inflammable material.

Kettles. The description of kettles, as a class, should treat of the manner of heating, the nature of the contents, the chances of the contents causing trouble, and the use of the kettle under pressure. It should be noted that the use of direct flames is not easily regulated so that the boiling over, or the boiling accompanied by sputtering, is a detail that should be described with the possibility that the surroundings will be spattered with the hot liquid.

Exposure. The terms *exposure* and *communication* are used to represent the outside fire danger, or, in other words, the hazard of other risks.

Exposure may be described from two standpoints, the danger to a risk from neighboring buildings, and the danger to these buildings from the risk. Exposure is generally classified as *opposite* and *adjoining* exposure, the former meaning one where there is an intervening distance between buildings, while the latter refers to those cases where the walls of the risk and exposure are close together. Exposure is in many cases described on the map or diagram of the risk, in which case a full written description is not required. At the same time, the inspector should always be prepared to describe exposure apart from the diagram or map.

The principal elements of exposure, *i.e.*, the features that should form the basis of a description are, *distance, character of buildings, relative height, walls*, and *fire stops*.

Distance. The element of distance applies only to cases of opposite exposure, and is a matter of stating the amount of separation between buildings, usually in feet.

Character of Buildings. Under the item character of buildings should be included the main features, such as, type of construction, height, area, general occupancy, and fire protection, particularly automatic sprinkler equipments.

Relative Height. The relative height, as an item of description, should cover the possibility of falling walls and overhead openings in the case of adjoining exposure.

Walls. The walls are really the principal thing in exposure. In case of adjoining exposure, the thickness of the wall and the condition of the brickwork should be described with respect to its ability to prevent fire from passing through. Actual openings in walls are self-evident sources of danger and should be carefully described. In the case of opposite exposure, the openings in walls are windows, doorways, and glass fronts. In the case of adjoining exposure, the discussion of the openings should include doorways and windows in use or not in use, pipe holes, shaft and belt holes, beams in party walls, chimneys, bridges, tunnels, show-windows, and other passages or means of communication for heat, smoke, or flames from one building to another.

Fire Stops. As an element of exposure, the discussion of fire stops should cover everything that tends to prevent a fire from spreading to or from damaging the adjoining or opposite buildings.

Fire stops are divided into *bricked-up openings* and *fire-resistant appliances* or *devices.*

A description of the *bricked-up openings* should cover the restoration of the solid walls by filling in with brick and mortar. When this has been done, details must be given as to the thickness of the bricked-up portion and the bonding, joining, or fitting of the new brickwork into the old brickwork in such a manner as to make a tight joint that will be proof against heat, smoke, or flame.

The *fire-resistant appliances* include fire doors, fire shutters, wire-glass windows, and outside sprinklers or water curtains. The facts brought out in the description of these appliances should include the construction, the materials, their method of operation and their maintenance.

DIAGRAM REPORTS

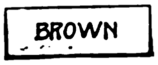
Fire Insurance Maps. In Fire Insurance the graphic description of a property has an important and an ever growing function; at present it is confined to a plan or simple diagram of the insured properties, adding certain simple devices for indicating such features of the building as may be conveniently described in this manner.

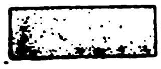
The map of a Fire Insurance risk gives the general location of the risk and its position relative to other risks. It also shows a *scale drawing* of the ground plan of the building, thus giving the dimensions and area of the building in a convenient way, and at the same time giving a perfect idea of its general contour and the relation of the subdivisions of the building. The standard scale used in these drawings is 1 inch to 50 or 60 feet, and as each line in the drawing is based on this scale it is possible, therefore, to obtain any dimension desired by reducing the length of the line to the scale adopted. The contour lines naturally represent the walls and positions of the building, and by varying the thickness of the lines they are made to represent different kinds of walls. Unfinished or incomplete walls are represented by dotted lines; open spaces in the line indicate where the wall is interrupted or where a window opening occurs. Color is used to a large extent to indicate the different forms of construction; certain symbols, which follow in a measure the shapes of the things they represent, are used to shorten the description; and of course the use of initial letters is too well known to be more than mentioned. These symbols, it must be understood, are purely arbitrary but, having become established and recognized, they form the "symbol" language of the inspector and must be studied in a practical way in order to be recognized when presented. These symbols together with a short description of each are given under the grouping system used for written reports.

Following this list of symbols is given an illustration of a typical inspector's map. This map is a copy of one issued in connection with the adoption of these symbols by the Fire Underwriters Uniformity Association and brings into use practically all the symbols needed. The only feature not brought out in the map is the color in the backgrounds, which indicates the kind of construction according to the scheme given on the following page.

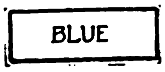
CONSTRUCTION

The construction of a building is indicated by the use of color, as follows:

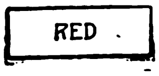




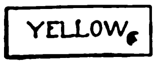
Brown on a map or plan represents *fireproof* construction. If the color is mottled or covered with small black dots, this indicates *reinforced concrete* construction.



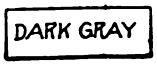
Blue represents *stone* construction, that is stone bearing walls or ordinary *concrete* walls and floors.



Red or pink represents *brick* construction.

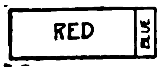


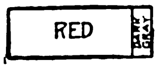
Yellow represents *frame* construction.

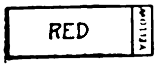


Dark gray represents *iron* construction.

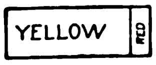
The use of color at the edge of a diagram denotes that the wall where this color is placed is different from the other walls of the building.



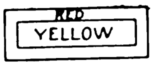




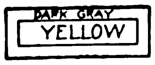
A red diagram with a blue strip across the front represents a *brick building with a stone front;* if the strip is gray the front is of *iron;* if the strip is yellow, the front is of *frame* construction.



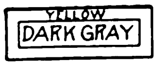
A yellow diagram with a red strip indicates *frame construction* with a *brick* front.



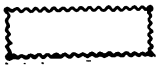
A yellow center with a red margin indicates a *frame building with brick veneer or brick-filled walls.*



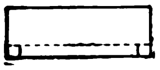
A yellow center with a gray margin represents a *frame* building, the outside of which is *metal.*



A gray center with yellow margin represents a building with *iron* framing, covered with *wood.*



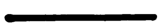
A diagram bordered by a crinkled line indicates a building covered with *corrugated iron.*



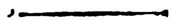
An *alley* or *driveway* through the building is indicated by a dotted line as shown.

WALLS

Walls are represented by lines in various forms as follows:

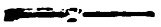


A solid thick line represents an *independent* wall.

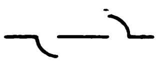


A solid thin line represents a *party wall.*

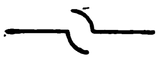
A broken line, *i. e.,* rather long dashes and short blank spaces, represents an incomplete *division* wall, *i. e.,* one that does not extend throughout the entire height of the building from basement to roof.



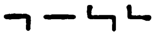
A distinct break in the line representing a division or side wall indicates an opening made by a *doorway* or *arch.*



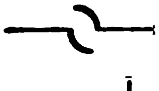
A small curved line or a short line at right angles as shown, indicates the presence of a *fire door,* the auxiliary line being placed on the side of the wall the door is on.



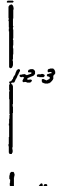
An auxiliary line on each side indicates a fire door on each side of the walls.



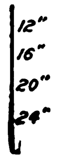
Either the solid curved or straight line indicates a *non-standard* fire door.



A double curved line is used to represent a *standard* fire door.



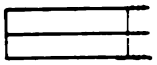
Figures placed at the break in the line indicate the *floors* on which the openings in the walls of the building occur.



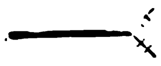
Figures representing inches are placed at some convenient spot along the wall line to indicate the *thickness of the walls.*

PARAPET

Parapets or fire walls are shown on plans by projecting the wall line beyond the point of intersection of two walls.

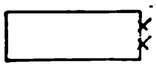


The parapet line is crossed by short lines, one for each 6 inches that the parapet extends above the roof.

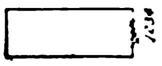


A heavy line with two parapet lines at an angle with each other indicate two independent adjoining walls with independent parapets.

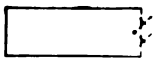
WINDOWS



A thin straight diagonal line run across the wall line and crossed at right angles by another short thin line indicates a *window opening.*

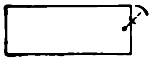


A vertical tier of windows is represented by a group of window lines, the number indicating the number of windows in the tier; *i.e.,* a building with four floors and a window at each floor would have four window lines. The floors on which the windows occur are determined by counting the window lines from left to right as one faces the building.

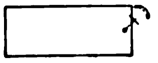


A little black dot on the inside end of a window line indicates a window opening on that side of two adjoining walls. If the black dot is missing, it means that there is no window on this floor.

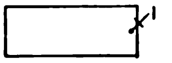
A sign placed at the outside end of a window line indicates that the window opening is *protected.* Curved lines indicate the presence of *fire shutters.*



A single curved line represents a ***non-standard*** fire shutter.

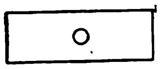


A double curved line represents a ***standard*** fire shutter.

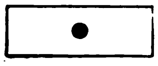


A straight line indicates the presence of *wire glass.*

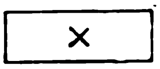
ROOFS



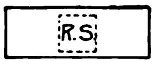
A small circle in the corner of a map or plan of a building indicates that the roof is *metal, tile,* or *slate.*



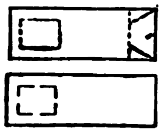
A round black dot indicates that the roof is *composition.*



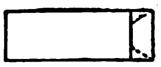
A small cross indicates that the roof is *shingle.*



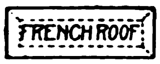
A dotted outline made on the diagram represents a roof structure, its relative size being indicated wherever possible, by the area enclosed by the dotted line. An abbreviation placed inside the dotted lines, indicates the type of structure.

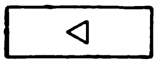


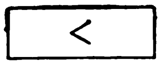
Where the construction of the roof structure differs from that of the rest of the building this is indicated, if possible, by the use of color.



Dotted lines running from the corners of the diagram represent a *mansard* roof, the lines being placed on the side where the mansard construction occurs. If the mansard covers the four sides of the building, this is indicated by a dotted line running entirely around the diagram.

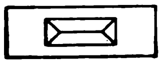




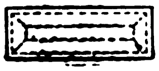


A small triangle in the center of the diagram is also used to indicate mansard construction the framing of which is *iron.* The angle sign is used to indicate that the framing of the mansard roof is of wood.

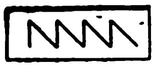
SKYLIGHTS



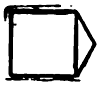
A skylight is indicated by a symbol whose shape suggests the outlines of a skylight.



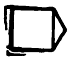
Broken lines are used to indicate the *Texas* or long *Monitor* skylight, the approximate area covered by the symbol indicating the size of the skylight.



A series of saw teeth indicates the presence of a saw tooth skylight.



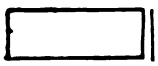
A flat triangle drawn on one side of a square indicates a *large floor opening with skylights above.*



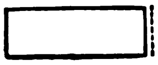
A smaller floor opening and smaller skylight is indicated by reducing the size of the symbol.

CORNICE

A cornice of a building is indicated by a line directly in front of the wall line.



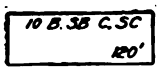
A straight line indicates a brick or metal cornice.



A broken line indicates a wood cornice.

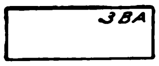
HEIGHT

The height of a building in feet is expressed in figures followed by a prime mark ('). Sometimes the height figures are enclosed in a circle.

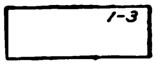


Height in stories
Height in feet

The height of the building in stories is indicated by numerals to represent the number of stories, followed by the abbreviation B. for basement, S.B. for sub-basement, C. for cellar, S.C. for subcellar and A. for attic.

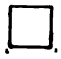


3 Stys., B. and Attic

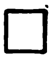


1 Story equal to 3

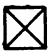
FLOOR OPENINGS



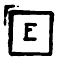
A hollow square is used to represent a *floor opening,* an initial letter being placed within the square to indicate the type of opening.



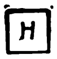
A square with solid, heavy lines represents a floor opening with *brick walls.*



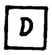
An X inside the hollow square represents an *Elevator.*



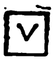
Elevators are also indicated by the initial *E* within the hollow square.



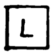
The initial *H* within the hollow square is used to represent a *hoistway* or *hatch.*



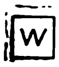
The letter D within the hollow square is used to represent a *dumbwaiter.*



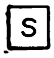
The letter V within the hollow square is used to represent a *ventilating shaft.*

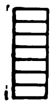


The letter L within the hollow square is used to indicate a *light shaft.*

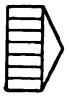


The letter W within the hollow square is used to represent a *well hole.*

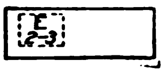




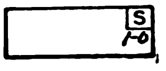
The letter S within the hollow square is used to represent a *stairway.* A stairway is also represented by a rectangular outline crossed by straight lines supposed to represent the stair steps.



The diagram just described, when augmented by a flat triangle drawn on one side indicates a stairway with a skylight above.



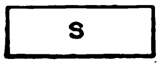
The representation of a floor opening by a broken line indicates that the floor opening does not pierce all floors.



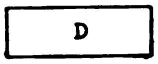
The floors that it does pierce are indicated by figures within the square, or, if there is no room within the hollow square, the figures may be placed outside the hollow square.

OCCUPANCY

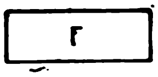
The occupancy of buildings, *i. e.*, the general nature of the business carried on, is usually indicated either by initial letters or by writing out the words in full.



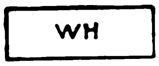
The letter S represents a *store*.



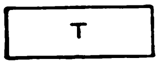
The letter D represents a *dwelling*.



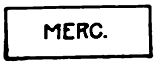
The letter F represents a *factory*.



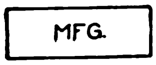
The letters W H represent a *warehouse*.



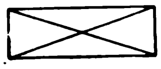
The letter T represents a *tenement*.



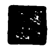
The abbreviation Merc. represents Mercantile.



The abbreviation Mfg. represents Manufacturing.

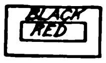


The use of two diagonals indicates stable occupancy.

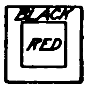


The square ruled with diagonal lines indicates a smoke house.

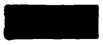
HAZARDS



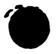
A small oblong figure with a red center and black edging is used to indicate a *retort*.



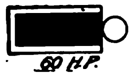
A smaller figure with a red center and a black edging is used to indicate an *oven*.



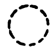
A solid black oblong figure represents a *horizontal boiler*, the *horse power* being indicated by numerals and the letters H. P.



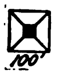
A solid black circle represents a *vertical boiler*, the H. P. being indicated as before stated.



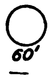
A thin line around the solid black oblong figure and the margin colored in red represents a *horizontal steam boiler* which is bricked in.



A small broken-line circle indicates a *cupola furnace*.

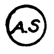


A small square containing diagonals and a black dot at their intersection indicates a *high brick chimney* or *stack*. The height of the stack is given in feet close by.

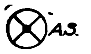


A small light-lined circle represents an *iron chimney*.

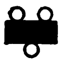
FIRE PROTECTION

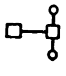


A small circle containing the initials A. S. represents an *automatic sprinkler* equipment in a building. This equipment is also indicated by writing *automatic sprinklers* across the plan.

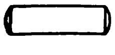


A small thin-lined circle with diagonals and a black dot at their intersection indicates an *automatic sprinkler riser*. Sometimes the initials A. S. are added.

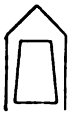




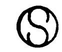
A small solid oblong figure, with smaller circles attached to indicate the number of hose connections, represents a *fire pump*. Another conventional symbol for the fire pump is given in the margin.



The symbol given in the margin represents a *sprinkler pressure tank*.

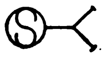


A symbol suggesting the outlines of a tank within a house is used to indicate a *tank house.*

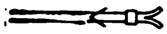


A small circle surrounding the initial S represents a *standpipe riser.*

The *Siamese connection* for fire department apparatus is indicated in two ways.

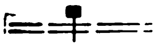


(1) A Y with the ends crossed, which is placed as close to the wall line as possible to indicate the relative position of the standpipe.

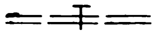


(2) The symbol given in the margin.

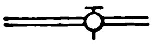
The various types of *valves* are indicated by symbols as follows:



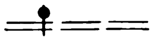
Underground valve requiring key to open.



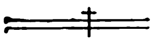
Ordinary gate valve.



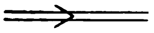
Globe valve.



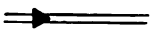
Post indicator valve.



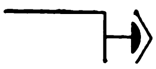
Indicator valve (any approved type).



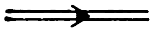
Check valve with apex pointing in direction of water flow.



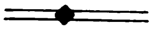
Check valve with alarm attachment.



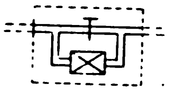
Alarm valve.



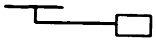
Alarm gong with hood.



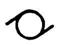
Dry valve.



The symbol in the margin indicates a *water meter* in *by-pass* located in brick pit.



The symbol shown in the margin represents an engine.

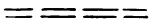


A small circle with two tangents represents a dynamo.

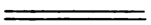
A small circle with one tangent represents a motor.

WATER SUPPLY

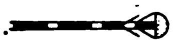
The various features of a water supply are indicated as follows:



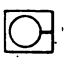
Water pipe (under ground).



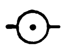
Water pipe (above ground).



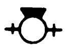
Section pipe *foot valve* and *strainer.*



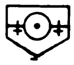
Dry or pipe hydrant showing non-standard hose house.



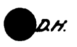
Two-way *frost-proof hydrant.*



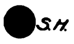
Frost-proof hydrant with steamer connections and with independent gates for hose connections.



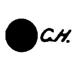
Frost-proof hydrant with hose valves on outlets: hydrant covered with standard hose house.



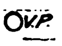
Two-way *public hydrant.*



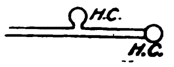
Single *public hydrant.*



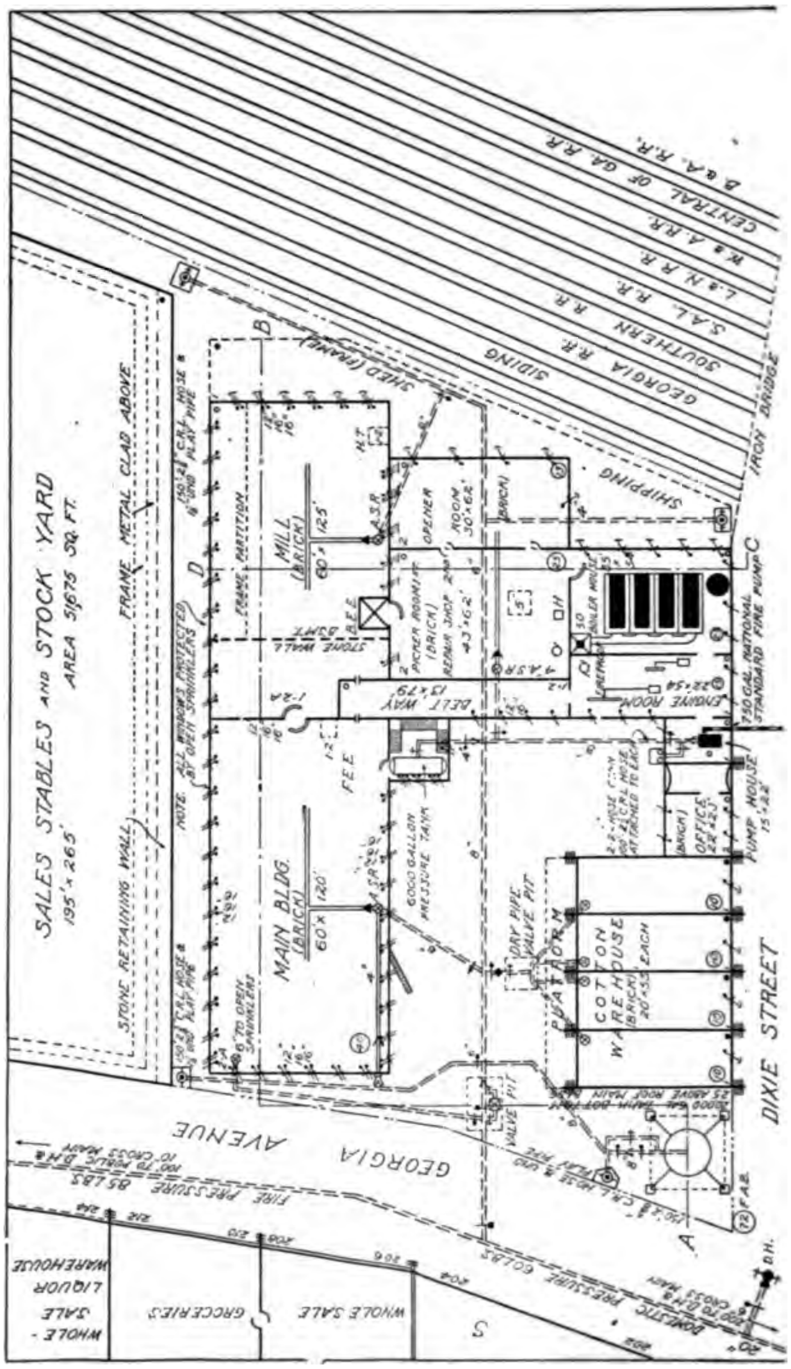
Chuck hydrant.

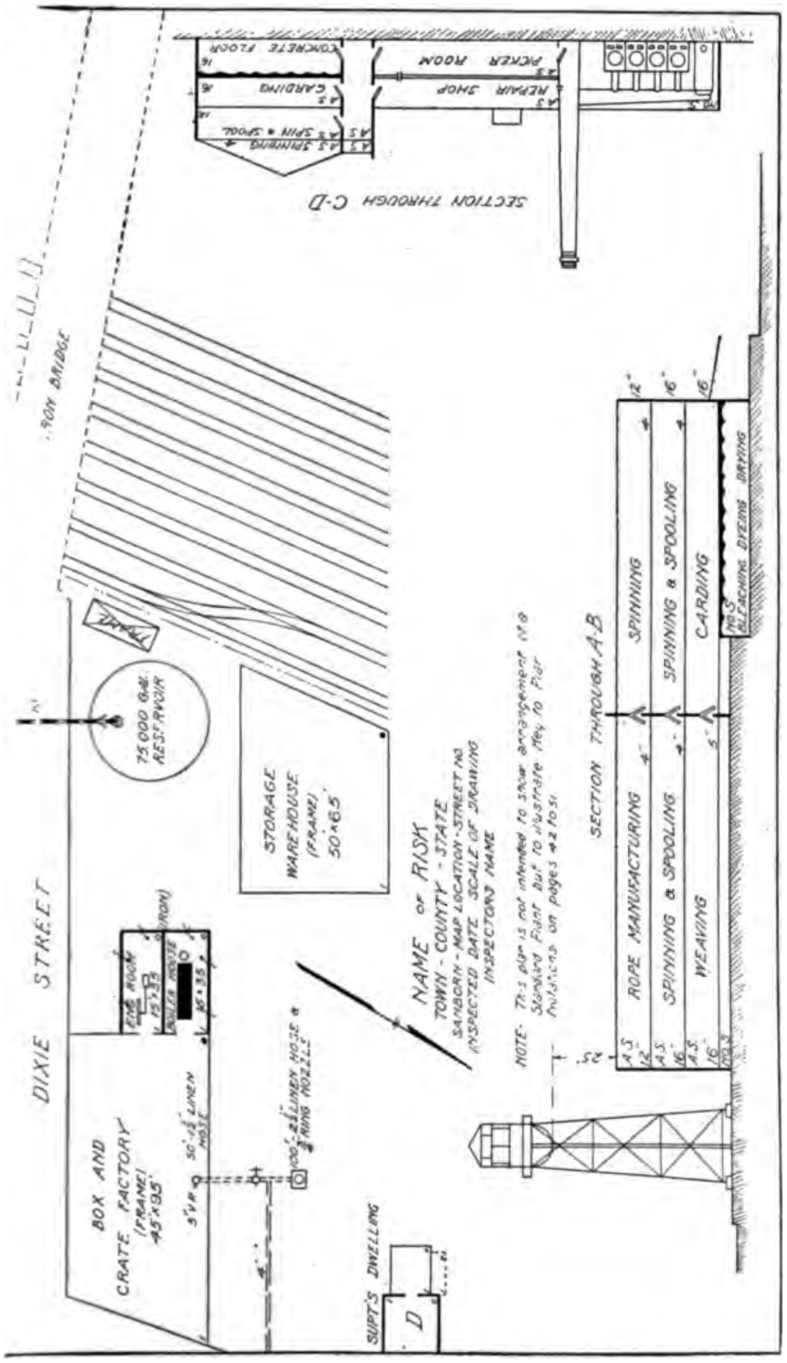


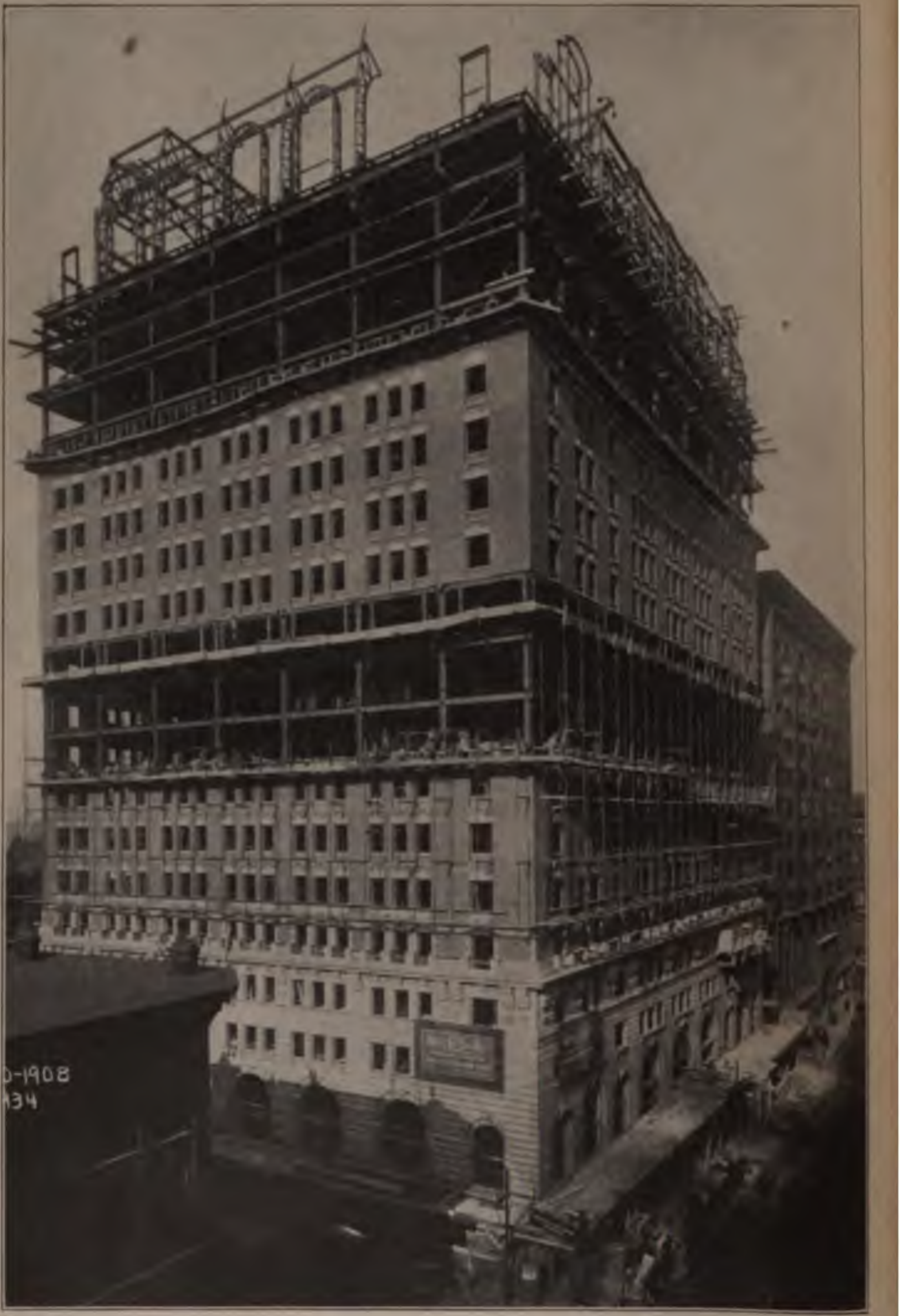
Vertical pipe.



Hose connection


SALES STABLES AND STOCK YARD
195' x 265'
AREA 51,675 SQ. FT.
FRAME METAL CLAD ABOVE
STONE RETAINING WALL
NOTE: ALL WINDOWS PROTECTED BY OPEN SPRINKLERS
MILL (BRICK) 60' x 125'
FRAME PARTITION
STONE WALL
MAIN BLDG. (BRICK) 60' x 120'
OPENER ROOM 30'x62'
PICKER ROOM (BRICK) REPAIR SHOP 2ND 43'x62'
BELT WAY 13'x79'
6000 GALLON PRESSURE TANK
DRY PIPE VALVE PIT
PLATFORM
COTTON WAREHOUSE (BRICK) 20'x33' EACH
OFFICE 22'x20'
PUMP HOUSE 15'x22'
ENGINE ROOM 22'x54'
BOILER HOUSE
750 GAL. NATIONAL STANDARD FIRE PUMP
SHIPPING
IRON BRIDGE
SHED (FRAME)
GEORGIA R.R. SIDING
SOUTHERN R.R.
S.A.L. R.R.
L.&N. R.R.
W.& A. R.R.
CENTRAL OF GA. R.R.
A.B.& A. R.R.
GEORGIA AVENUE
DIXIE STREET
FIRE PRESSURE 85 LBS.
DOMESTIC PRESSURE 60 LBS.
WHOLESALE GROCERIES
WHOLESALE LIQUOR WAREHOUSE
A
B
C
D


DIXIE STREET
IRON BRIDGE
75,000 Gal. RESERVOIR
STORAGE WAREHOUSE (FRAME) 50×65
BOX AND CRATE FACTORY (FRAME) 45×95
ENG. ROOM 15×35
BOILER HOUSE 15×35
(IRON)
5"V.R.
50'-1½" LINEN HOSE
100'-2½" LINEN HOSE & ¾" RING NOZZLE
SUPT'S DWELLING
D
NAME OF RISK
TOWN - COUNTY - STATE
SANBORN - MAP LOCATION - STREET NO.
INSPECTED DATE SCALE OF DRAWING
INSPECTORS NAME
NOTE - This plan is not intended to show arrangement of a Standard Plant but to illustrate Key to Plan notations on pages 42 to 51.
SECTION THROUGH A-B
ROPE MANUFACTURING
SPINNING
SPINNING & SPOOLING
SPINNING & SPOOLING
WEAVING
CARDING
M.S. BLEACHING DYEING DRYING
A.S. 12"
A.S. 16"
A.S. 16"
M.S.
4"
5"
12"
16"
16"
25'
SECTION THROUGH C-D
CONCRETE FLOOR
CARDING
A.S. SPINNING & SPIN & SPOOL
REPAIR SHOP
PICKER ROOM



LASALLE HOTEL, CHICAGO, IN PROCESS OF CONSTRUCTION
An Excellent Type of Modern Fireproof Construction. Internal Construction Is Protected Steel, Exterior Brick and Stone
Holabird and Roche, Chicago, Architects. George A. Fuller Company, General Contractor

FIRE INSURANCE INSPECTION

PART II

CONSTRUCTION OF BUILDINGS

GENERAL SPECIFICATIONS

A study of the construction of buildings with reference to Fire Insurance should be made from the standpoint of its purposes and needs and would naturally fall into two main divisions—the building and the contents.

BUILDING CLASSIFICATION

What distinguishes a mere structure from a building is not of any particular moment. Four walls and a roof is sometimes used as a definition of a building, but such structures as sheds and trestles would seldom be misunderstood as buildings.

To distinguish buildings, certain terms are used which are chosen principally as an indication of the construction, viz, *frame; brick* or *ordinary; stone; iron; mill-constructed;* and *fireproof* including *steel* and *concrete*. This classification is amplified in the chart.

These terms mean different things, depending on the person using them and the locality in which they are used. Accordingly, the following definitions of them are intended to be only suggestive and to be corrected or altered as needed. The basis of this classification is the kind of wall, except in the case of the Mill-constructed and the Fireproof, which have special features to distinguish them.

Frame Building. A frame building is built entirely of wood, including walls, posts—called studs, and covered with boards or other materials—and beams or floor supports; the partitions and the finish of the building are also of wood or of lath and plaster. The walls of frame buildings sometimes have the space between the studs filled in with bricks and in such cases the building is called a *brick-filled* building or *brick-nogged* building. This should not be called a brick-and-frame building, which is a different thing.

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CHART

Classification of Buildings

Class	*Title*	*Description*
FRAME	Frame Building	Wood walls, covered with boards
	Frame Building	Wood walls, brick-filled or "nogged"
	Frame-and-Brick Building	Wood wall, with brick outside or veneer
	Frame-and-Plaster Building	Wood walls covered with mortar, plaster, stucco, or cement
	Frame-and-Iron Building	Wood walls covered with iron, usually corrugated iron
BRICK	Brick Building	Brick walls, ordinary (joisted) floor construction
	Brick-and-Stone Building	Brick walls, stone front (facing or veneering)
STONE	Stone Building	Stone-bearing walls, ordinary (joisted) floor construction
IRON	Iron Building	Iron framing, iron covering
	Iron-and-Frame Building	Iron framing, wood covering
MILL CONSTRUCTION	Brick Mill-constructed Building	Brick walls, floor construction of heavy timbers
	Frame Mill-constructed Building	Wood walls, floor construction of heavy timbers
*FIREPROOF	Skeleton Construction	Brick-bearing walls, steel or iron frame and incombustible floor arches
	Cage Construction	Steel frame carrying the walls and incombustible floor arches
	Concrete Construction	Walls and interior construction of concrete
	Reinforced Concrete Construction	Walls and interior construction of concrete reinforced with steel

In a brick-and-frame building one or more walls are of frame construction or brick construction. The most common form of this kind of building is one in which the front wall is brick, while the side and rear walls are wood; sometimes it is a side wall that is brick. In case a building has three walls of brick, it can properly be called a brick building, but special reference must be made to the one wood or frame wall.

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*For a detailed discussion of Fireproof Construction the reader is referred to Fireproof Construction, Parts I, II, III, and IV.

Another form of mixed brick-and-frame building, but for all practical purposes to be considered a frame building, is one with wood walls, covered on the outside with one thickness of brick as a veneer or covering.

It is the wall proper or the framework of the wall which decides whether a building is brick or frame. For this reason, a building with plaster or cement walls attached to or resting on a wood frame must be considered a wood building, but it should be described as a frame-and-plaster building. The same thing is true when the wood frame is covered with iron, as in the case of many sheds, while a common form of pier construction has an iron frame but a wood covering.

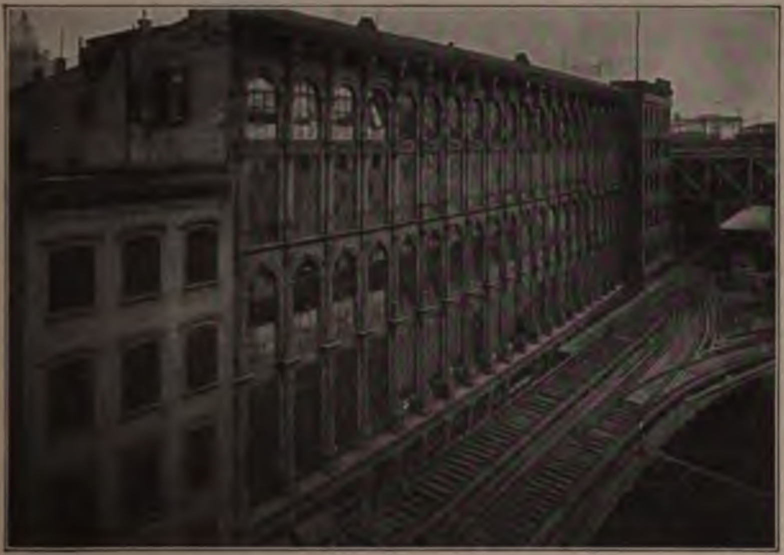


Fig. 1. Building with Cast-Iron Front

Brick or Ordinary Building. By a brick building, as the term is generally used, is meant a building with brick walls and ordinary floor construction, that is, the floor has no extra heavy timbers, as in Mill Construction, nor is it built of incombustible materials, as in Fireproof Construction. Such a building has, in addition to its brick walls, which may have an outside covering or layer of stone for decoration purposes, floor beams of wood, and partitions and finish of wood, or lath and plaster. Sometimes a brick building will have one front or side built of cast iron, Fig. 1, or wood, or even glass. These special conditions, however, do not affect its classification as an ordinary brick building.

Stone Building. A building which has brick walls covered with stone, as a veneering or outside facing, is properly a brick building and should be so called, in order to avoid the confusion which must result from using the same term *stone* for one building which actually has stone walls, and for another building which has only a stone facing to brick walls. The latter should be distinguished as a brick-and-stone building, while the building with stone walls, which actually carry the floor loads, should be distinguished as a stone building.

A building which has walls of concrete and an interior construction similar to that of an ordinary brick building, should be distinguished from a building entirely of concrete, which, therefore, can be placed in the Fireproof or incombustible class of buildings. A building with concrete walls and wood interior construction must be classed as a building of ordinary or non-fireproof construction.

Iron Building. The iron building, usually consisting of an iron frame for the walls, covered with corrugated iron or other form of sheet iron, also belongs in the ordinary class of buildings.

Mill-Constructed Building. This type of building is also generally called *slow-burning*. Its distinguishing feature is the use of large supporting timbers, plank flooring, and open or unconcealed construction.

Fireproof Building. Fireproof, Fire-resistant, or Fire-resistive buildings are classed as those structures which do not use wood in any part of the structural supports, that is, the walls or the interior supports or the construction of the floors. This applies to all buildings using a steel or iron framework, either for the walls, or the columns, girders, and beams, and also to buildings using concrete with or without steel reinforcing.

Fireproof buildings, as a rule, have walls of brick, but they are seldom classed as brick buildings, for, like the mill-constructed building, their special features necessitate a separate classification. A precise test of what does or does not constitute a fireproof building is not available since it is in most cases a matter of individual opinion. A general rule which is useful as a basis of classification is that *fireproof construction assumes that the bearing and supporting members of a building are non-combustible, usually brick, concrete, iron, or steel.* In other words, the walls, columns, girders, beams, and the filling between the beams are of these materials. This much, at least, constitutes the essentials. Whether the iron work is protected or not, or the vertical shafts through the building are also of fireproof construction, or the roof is an ordinary wood roof, appear to be details affecting the degree of fireproof construction.

Concrete Building. Concrete buildings are much more common in Europe than in the United States, but the number here is rapidly increasing. In most cases, steel is used in connection with the construction, so that concrete buildings are already sub-classified under the heading of reinforced concrete. A strictly concrete building meets the requirements of fireproof construction and accordingly must be classed as a fireproof building, but for purposes of distinction, it is perhaps better to put them in a separate class.

Concrete buildings have the walls built of concrete with or without reinforcement, thereby replacing the brick walls of the ordinary building and the steel frame of the fireproof building. They also have the interior construction, such as, columns, girders, beams, floors, and partitions, of concrete, thereby taking the place of wood, steel, hollow tile, or other building materials which are used in the other types of buildings.

BUILDING MATERIALS

A knowledge of the essential features of the more important building materials is necessary in order properly to describe building construction according to the requirements of Fire Insurance.

Brick. Bricks are made of a mixture of clay and sand, which is moulded into the desired sizes and shapes, then dried and burnt to a proper hardness in a kiln. Bricks are classified as follows: *common* brick, which is used for ordinary building purposes; *face*, or *front* brick, which is a finer grade of brick used for front walls; *fire* brick, which is made of special clays and used for lining furnaces, chimneys, and other places where excessive heat is a condition; *glazed*, or *enameled* brick, which is used for lining bath rooms, elevator and stair shafts, and other places where a smooth and waterproof surface is desired.

Bricks are made in various sizes, the standard size for ordinary brick being 8¼×4×2½ inches, and for face brick being 8⅜×4⅛×2¼ inches, Fig. 2. English brick comes in different sizes from this, and in various parts of the country other sizes may be found. Good brick should be sound, free from cracks, flaws, stones, and lumps; it should be hard and well burnt, red in color, and give a ringing sound when struck with a trowel.

Sand. Sand for building purposes should be clean, sharp, gritty, and free from dirt, loam, clay, earthy matter, and large stones. The fineness of sand is determined by standard samples kept in building departments having jurisdiction.

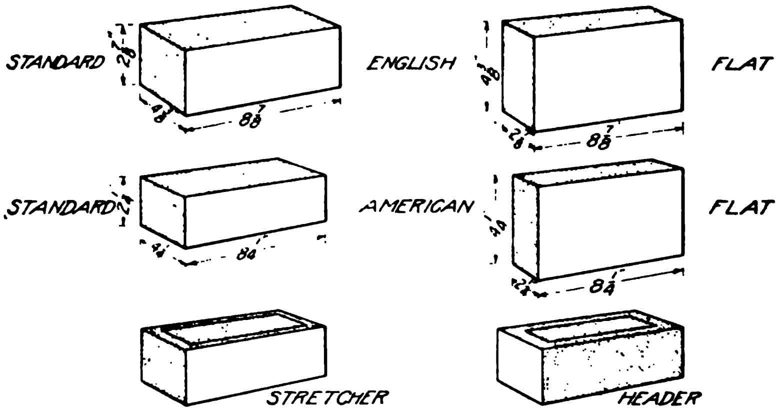


Fig. 2. Standard Brick Sizes

Mortar. Mortars are of two kinds: *lime* mortar and *cement* mortar. Lime Mortar usually consists of one part of lime and not more than four parts of sand. Lime as used for a building material is made by the calcination (heating to redness) of limestones. Good lime should be well burnt, and free from cinders and clinkers; it should come in the shape of hard lumps with little dust, and should slake readily in water, forming a smooth paste.

Cement mortar is usually made of one part of cement and three parts of sand. It should be used immediately after mixing. The cement and the sand should be measured and thoroughly mixed before water is added. Cement to be in proper condition should be finely ground and free from lumps.

Two kinds of cement are used: *Portland* cement and *natural* cement. Portland cement, which receives its name from its resemblance to Portland stone, a well-known English building stone, is a manufactured cement made by mixing carbonate of lime, alumina, silica, and iron. As compared to natural cement, it is slow setting, but has much greater strength. Natural cement is made from a natural rock, and sets very quickly, but is not as strong as the other cement.

The distinction between Portland and other cements in some places—New York City for instance—is determined not by their manufacture, but according to the way they meet specific tests of their tensile strength.

Cement mortar is used for mason work below grade, for construction work in damp places, and for heavily-loaded piers or walls.

Cement and lime mortar is usually made of one part of lime, one part of cement, and not more than three parts of sand to each of the other two.

Concrete. Concrete is an artificial stone or rock made by uniting broken stone, gravel, cinders, or other *aggregates*, as the pieces are called, by means of cement or lime, which is the binding or solidifying element. The proportions of aggregates and binding elements vary greatly. The New York Building Code, for instance, requires, for concrete foundations, at least one part of cement, two parts of sand, and five parts of broken stone, or in place of stone the same proportion of sand.

Building Stones. The principal building stones likely to come under the notice of Fire Insurance men are the following:

Granite. Granite is a hard and grainy or granular stone composed of quartz, feldspar, and mica.

Gneiss. Gneiss is a bastard granite used in some places for foundations, its special characteristic being the arrangement of its ingredients in parallel layers.

Limestone. Limestone is composed of carbonate of lime and is used for exterior or face walls.

Marble. Marble is a crystallized limestone, capable of taking a good polish. In the form of rough surfaced blocks it is

adaptable for exterior walls of buildings and, when sawed into thin slabs and polished, it is much used for decorative or ornamental purposes on the interior wall and partition surfaces of the building.

Sandstone. Sandstone is composed of grains of sand cemented or bound together by silica, oxide of iron, carbonate of lime, or other substances. In New York City, especially, brown sandstone was used very extensively at one time, and a large number of buildings at the present day show the use of this stone.

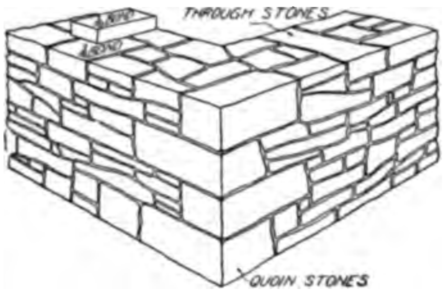


Fig. 3. Rubble Masonry

Slate. Slate is used for roof coverings and the treads and landings of stairs.

NOTE.—Although building stones are, of course, not an inflammable material, yet their disposition to crack and spall under the influence of fire makes them very easily damageable, beyond repair, by heat and flame.

Stone Work. Stone work in building operations is distinguished or classified as follows:

Rubble Stone. Rubble stone, Fig. 3, is rough uncut stone used on the outside walls of buildings.

Ashlar. Ashlar, Fig. 4, is cut stone used for the outside facing of a wall, and is furnished plain, axed, or ornamental.

Quoins. Quoins are stones used at the corners of a building, Fig. 3.

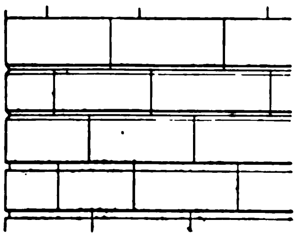


Fig. 4. Ashlar Masonry

Jambs. Jambs are stones at the sides of a door or window opening.

Trimmings. Trimmings is a term applied to the small stones used, such as moldings, caps, lintels, sills, ornamental courses, and other stone work, excepting ashlar.

Sills. Sills are stones placed at the bottom of a window opening in a stone or brick wall, as well as at the doorstep or threshold of a door opening.

Lintels. Lintels are the stones over door or window openings.

Bond Stone. Bond stone is the stone used at intervals in piers.

Cap Stone. Cap or crown stone is the stone placed at the top of a pier.

Key Stone. Key stone is the stone at the center of an arch.

Templates. Templates are stones used to give a bearing or rest under the ends of beams or girders in order to distribute the weight or pressure evenly.

Terra Cotta. Terra cotta is a material very much in use and more generally called tile or clay. It is made of practically the same material as brick.

The clay from which terra cotta is made is first mined, then put through certain processes, moulded and carved to the desired shape, form, or design, and then dried and burnt. Terra cotta blocks or hollow tile blocks, Fig. 5, are formed into the shape of a hollow shell, which is connected and braced by partitions or ribs. Terra cotta is used for decorative pieces, while the tiles or blocks are especially used to make floor arches or floor constructions and partitions of fireproof character, Figs. 6 and 7.

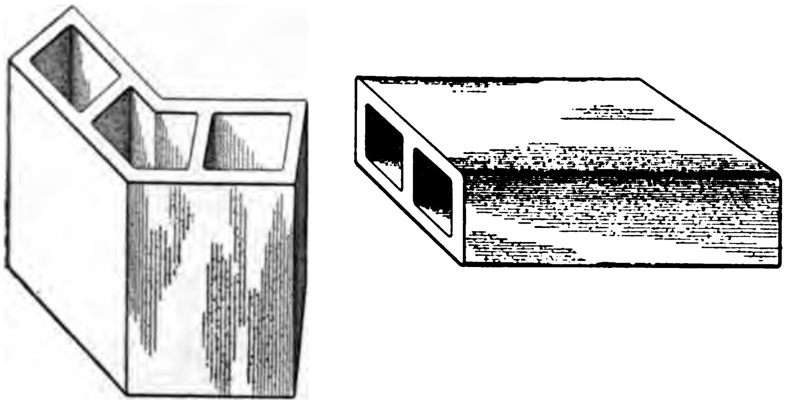


Fig. 5. Hollow-Tile Blocks

Lumber. Lumber as a building material can be described briefly according to the kind of wood and its uses, as follows:

For the light framing of buildings, such as dwellings and tenements: *spruce, white pine, northern yellow pine,* and *hemlock.*

For the heavy framing, such as posts, girders, and beams: ***Georgia pine, Oregon pine,* and *white oak.***

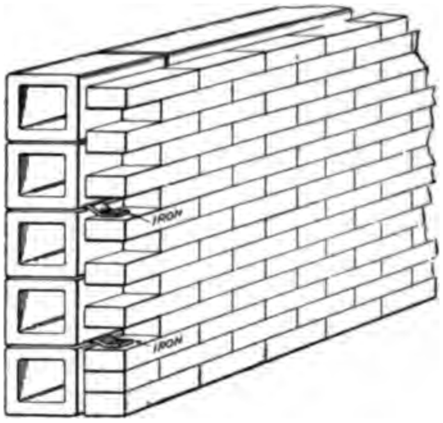


Fig. 6. Tile Blocks Used as Fireproof Protection

For sash, doors, and base, for veneers, and for woodwork which is to be painted: *white pine, poplar,* or *white wood.*

For flooring: *white oak, maple,* and *Georgia pine.*

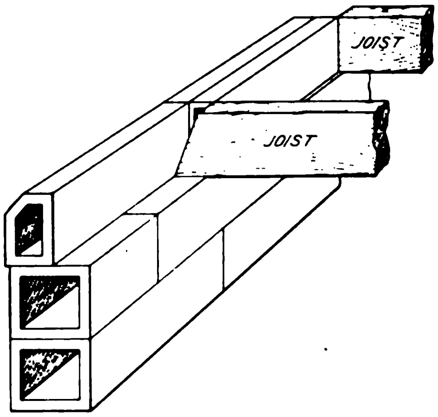
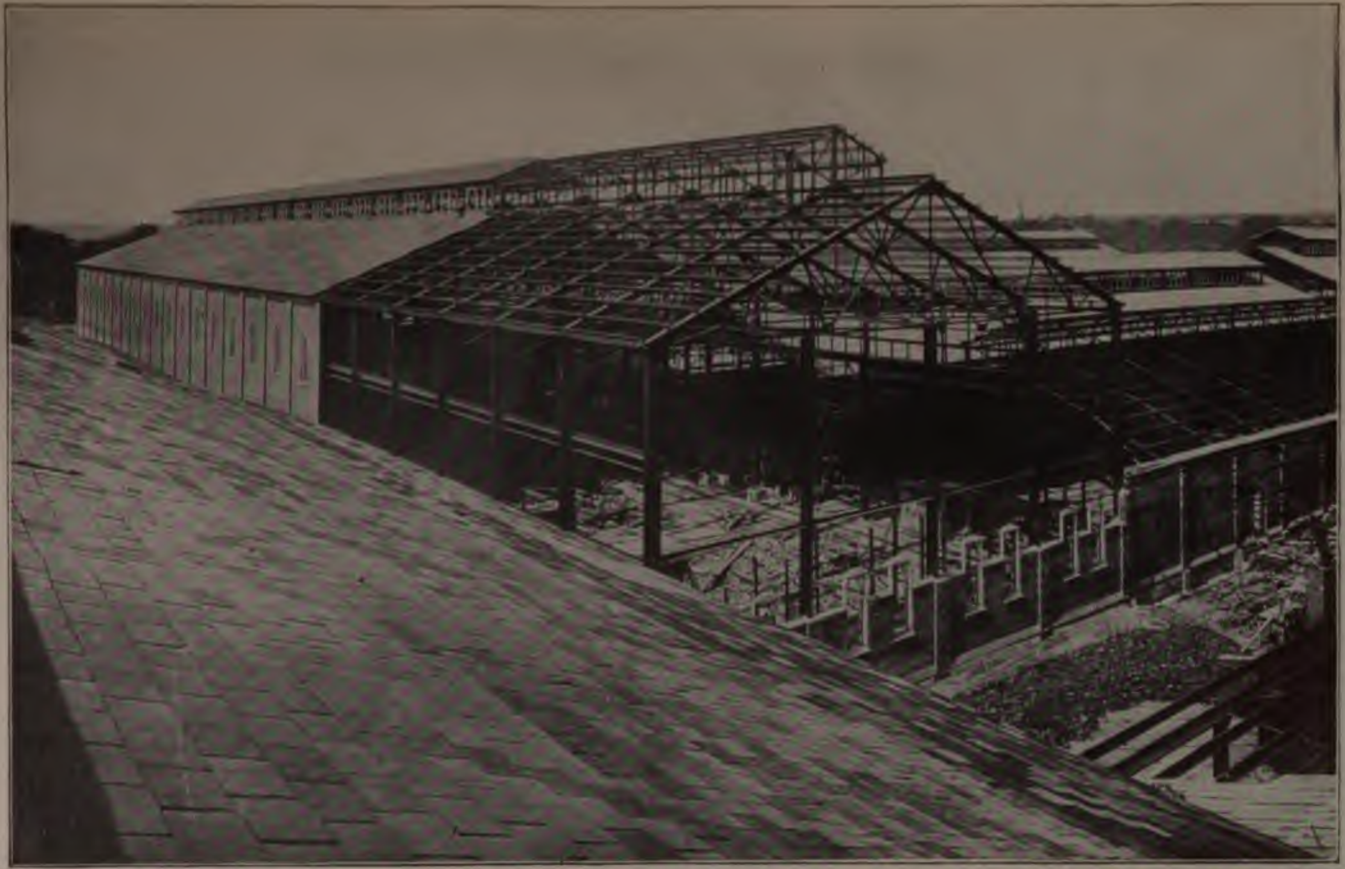


Fig. 7. Fireproof Tile Partitions

The standard sizes of building lumber are as follows: ***Framing timber,*** even sizes 4×6, 6×8, 10×12 inches; ***floor joists and planks,*** 2, 3, 4 inches; flooring, 1 inch, ⅞, 1¼, 1⅛.



BUILDINGS FOR THE PITTSBURG PLATE GLASS COMPANY, CRYSTAL CITY, MISSOURI

Grinder and Polisher building, 408 ft. by 532 ft.; Laying Yard building, 100 ft. by 578 ft.; Lehr building, 68 ft. by 475 ft. and 114 ft. by 171 ft.; Stripper building, 90 ft. by 408 ft.; Warehouse, 153 ft. by 304 ft. and 90 ft. by 173 ft. Total weight of steel work, 6,280,000 lbs.

Courtesy of American Bridge Company.

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Veneer. A veneer is a thin strip or sheet of wood cut from a log by a shaving machine, capable of cutting 30 strips to the inch.

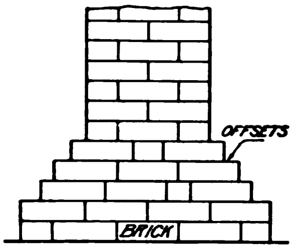

Fig. 8. Foundations all of Brick

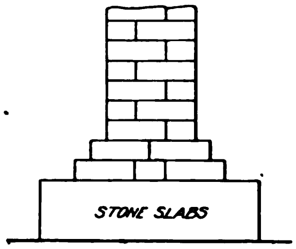

Fig. 9. Foundation with Stone Base-Slab

FOUNDATIONS

Foundations for Fire Insurance purposes are limited to those above ground, Figs. 8, 9, and 10, caisson and pile work not being considered.

Soils. The ground or earth on which foundations rest is generally called *soil*, and is classified or distinguished as follows: *Soft clay, clay and sand, loam and clay* or *loam and sand, coarse sand, stiff gravel* or *hard clay*, and *rock*.

The bearing or sustaining power of the different soils is described in terms of loads of one ton per square foot of superficial surface. Table I gives bearing capacities as taken from the Model Building Code of the National Board of Fire Underwriters.

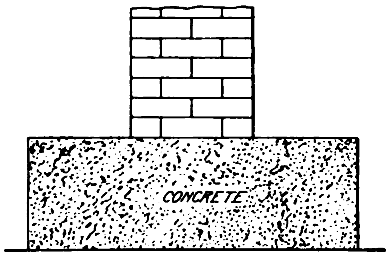

Fig. 10. Foundation with Concrete Base-Slab

TABLE I

Bearing Capacities

Material	Load per Square Foot
Soft clay	1 ton
Ordinary clay and sand together, in layers, wet and springy	2 tons
*Loam, clay, or fine sand, firm and dry	3 tons
Very firm, coarse sand, stiff gravel, or hard clay	4 tons

*Or as otherwise determined by the Commissioner of Buildings.

When a doubt arises as to the safe sustaining power of the earth upon which a building is to be erected, it is customary for borings to be made or tests made of the soil.

WALLS AND PIERS

For Fire Insurance purposes the importance of a thorough knowledge of walls, piers, and columns cannot be overstated. They are not only a great factor in preventing a collapse or total destruction of a building, but the walls must be built to contain a fire within themselves, as well as to keep out a fire from the adjoining building by preventing the heat from passing through the adjoining walls.

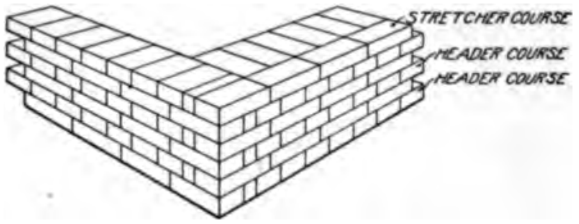

Fig. 11. Method of Bonding Brick Masonry

In the study of walls, the first step should be to find out how a wall is built. This may be observed at almost every building operation, but for present purposes it may be stated that a wall is started from the foundations, carried to the height of the building, and then carried a few feet higher in order to make the parapet. As the wall is erected from floor to floor, all openings for doors, windows, flues, recesses, and channels are made in the brickwork.

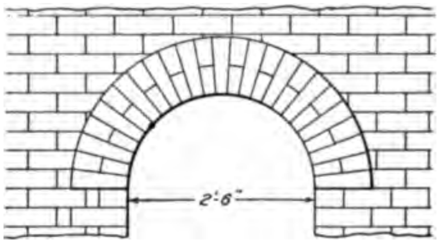

Fig. 12. Common Form of Brick Window Arch

The strength of walls or the bearing capacity is established by the building laws in force where the building is being erected. The thickness of the walls and the materials composing them are defined according to the purpose and the use to which the building will be put.

The specifications for walls have practically been standardized and can be found by reference to the National Board Building Code or other building laws. The points of a good wall are: ***brickwork well done***, that is, good workmanship; ***good mortar*** used; ***good bricks*** used; and walls ***built to a line*** and carried up ***plumb*** and ***straight*** and with proper ***bonding*** or ***anchoring***.

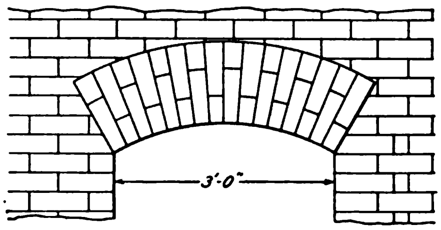

Fig. 13. Another Form of Brick Window Arch

Bonding is a method of laying bricks so as to avoid vertical joints throughout a section of the wall. Bricks are laid as stretchers or headers, Fig. 11, the headers being the bricks with their small ends facing out. Each layer of brick is spoken of as a *course*, and to give a good bonding for the wall as a whole, the usual rule is that every sixth course shall be a header course.

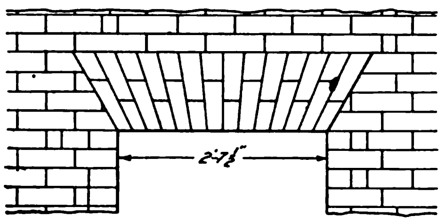

Fig. 14. Keyed-In Brick Lintel

Walls are anchored, either by being bonded into another wall, or by the use of wrought-iron tie anchors put in place at every six feet.

A good wall requires that the area of openings, such as doorways, windows, flues, recesses, and channels, shall be kept as low as possible, because they reduce the strength of the wall. A safe limit for wall openings is placed at 30 per cent of the whole area, unless the wall is extra thick or strengthened by pier or pilaster construction.

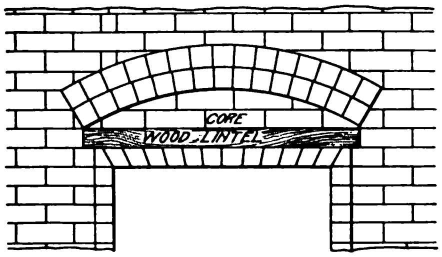

Fig. 15. Combination Brick and Wood Window Arch

The use of timber in walls is not considered good practice. For the top of windows and doorways, it is better to have the brickwork arched, Figs. 12 to 15 inclusive, or the lintels that are put in place should be of stone, iron, or steel. Another point of good practice is the use of templates to carry girders and beams.

Walls are classified and described as *bearing* and *non-bearing* walls.

Bearing Walls. Bearing walls are those on which the beams, girders, or trusses rest. They are further distinguished as *independent* and *party* walls. Independent walls are those which are used by only one building, that is, they carry only one set of beams or girders. Party walls are those used by two buildings, that is, they carry two sets of beams or girders, one set on each side of the wall.

Non-Bearing Walls. Non-bearing walls are those which support only their own weight, that is, no beams or girders rest upon them. Special types of non-bearing walls are as follows:

Curtain Walls. Curtain walls are those walls which are built in between piers or columns, but not carried on girders or horizontal supports.

Enclosure Walls. Enclosure walls are those walls which are built in between piers or columns, and are carried on girders from floor to floor. This is the usual wall construction for the outside walls of fireproof buildings which are built of a steel frame or cage.

Division Walls. Division walls are those walls which are built within the interior of a building, usually running fore and aft or sometimes across the building. They divide a building into sections and in many cases are erected where the distance between the outside walls is too wide to be spanned by beams or girders. A standard division wall, according to Fire Insurance requirements, should extend from the basement to the roof and have a parapet above the roof.

Parapet Walls. Parapet walls are the extension of walls above the level of the roof. For dwelling buildings they are carried two feet above the roof and are built 8 inches in thickness. For commercial or manufacturing buildings, parapet walls are carried 3 feet above the roof and are constructed 12 inches in thickness. All parapet walls should be coped with stone, terra cotta, or cast iron.

Measurement of Walls. In measuring walls or stating the thickness or dimensions of walls, it is the accepted Fire Insurance practice to give the measurements from the first story to the roof inclusive; that is, the basement or foundation measurements are seldom called for. The thickness of walls at each story is given, and when a wall is faced with stone—what is called ashlar—the stone is counted in the thickness of the wall only if it is 8 inches thick and bonded into the backing or the wall proper.

When hollow bricks are used on the inside of the wall, they count in the thickness of the wall, if they are hard burnt and the same size and dimensions of ordinary brick. Terra cotta or hollow-tile blocks, used for furring purposes, Fig. 16, should not be counted in giving the thickness of the wall.

Piers. Piers are built of brick or stone. It is usual to require the use of cement mortar, and to require the placing of bond stones or bond plates of iron on piers at regular distances in order to produce an even bearing surface. Cap stones or iron plates are also required for piers.

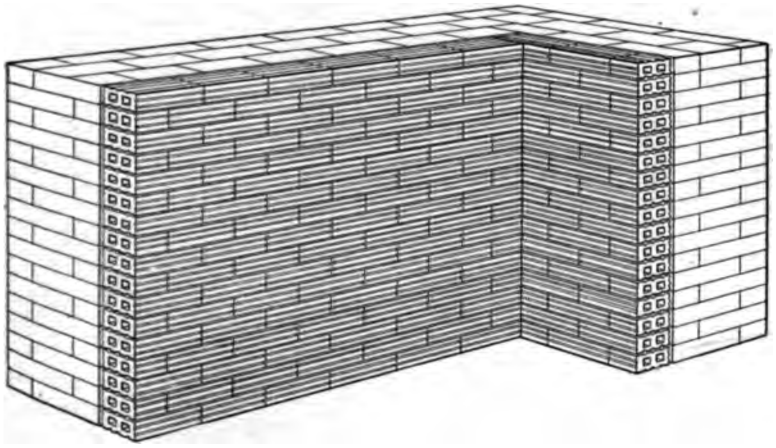

Fig. 16. Wall Showing Terra Cotta or Hollow-Tile Facing

Piers are described as *isolated* piers and *wall* piers. Isolated piers are virtually brick columns standing alone and are generally used as foundation supports for iron columns above. Wall piers are practically extra thick sections of a wall at the places where beams, girders, columns, or arches rest.

A special feature of piers from a Fire Insurance standpoint is the protection for the bond and cap stones. Such stones are especially liable to be damaged by fire so that they disintegrate sufficiently to destroy the value of the pier as a foundation support and cause settlement of the supporting columns above. It is customary in many places, therefore, to install fire protection for the stones in piers. This protection is similar to the protection for steel work and usually consists of wire, lath, and cement or concrete to the depth of 2 inches at least.

FLOOR CONSTRUCTION

A building whose floors or roofs are supported directly on the outside walls is a simple form of weight-bearing construction, called wall-and-beam construction. The horizontal support of the building is by means of beams, the ends of which rest on brick walls at the side, which, in turn, furnish the vertical support.

As the maximum load which wood beams can safely sustain in proportion to their length is quickly reached, wall-and-beam construction is limited to narrow widths or spans, which means that if no other method were available, buildings would be narrow, because there would have to be a wall about every 25 feet. The necessity of using bearing walls may be avoided, however, by means of the *column-and-girder form* of construction, involving the use of columns or posts as vertical supports and girders as horizontal supports, the two in combination having practically the same duty as a brick wall.

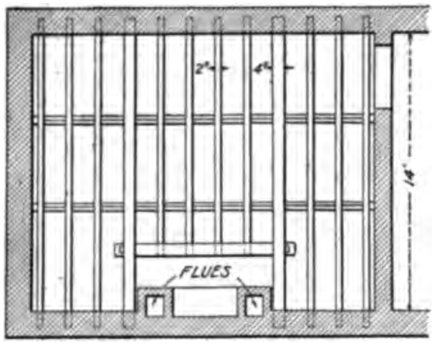

Fig. 17. Floor Plan Showing Girders and Beams

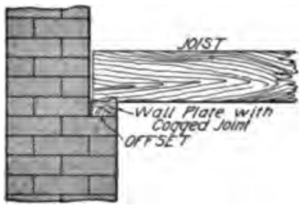

Fig. 18. Form of Joist Support

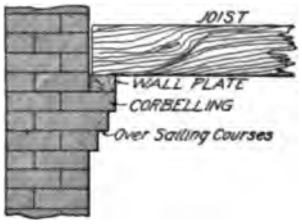

Fig. 19. Joist Supported by Brick Corbelling

Beams. A beam, or joist as it is sometimes called, is a horizontal bearing member or part of a building, which extends from wall to wall, or from wall to girder, or from girder to girder. It is the usual support for a floor, Fig. 17. In constructing a floor the beams which are set on edge with the ends resting on whatever bears them, Figs. 18, 19, and 20, are kept upright by braces placed between them in the fashion of a cross, this cross-work being known as bridging, Fig. 21. In some cases the ends of the beam are hung in hangers or irons, called *stirrup irons*. In other cases, the beam is set into the girder by cutting out a space for it, a method known as *tenoning*.

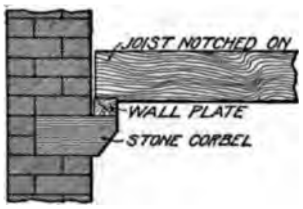

Fig. 20. Joist Supported by Stone Corbel

The setting or bearing spaces for beams are usually placed at 4 inches, that is, the end of the beam for a distance of 4 inches must rest on a bearing place. The size and thickness of beams vary according to the weight that they must bear; however, beams less than 3 inches thick are not considered safe. The depth or height of the beam, when placed on edge, will vary from 8 inches, which is the dimension used for roof beams, up to 16 inches or more, which is the dimension used for regular floor construction. A fireproof filling is sometimes used between beams to deaden sounds and to increase the fire-resistance of the floor, Fig. 22.

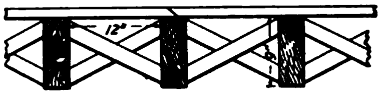

Fig. 21. Method of Bridging Floor Joists

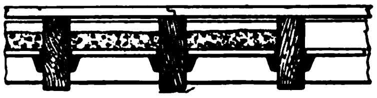

Fig. 22. Section of Floor Showing Fireproof Filling

Self-Releasing Beams. For Fire Insurance purposes it is desirable to have the floor of a building, when it collapses, fall without also pulling down the walls or vertical supports. It is evident that a beam whose end is a right angle, when forced downward would tear out a number of bricks and crack or unsettle several courses of brick as well. If this happened with a number of beams close together or at the same time it might tear out a sufficient section of the wall to cause a buckling or settling of the whole wall or at least a large portion of it. To prevent this, or at least to reduce the damage to a minimum, it is customary to cut the end of a beam which is placed in a brick wall, on a diagonal or bevel, so that if a beam does pull out, it will unsettle only a small part of the brickwork. It is the bevel of the end of the beam, therefore, that is known as the self-releasing feature.

Beams in Party Wall. Fire Insurance is greatly concerned with the possibility of fire passing from one building into another through the side walls. In the case of two independent walls, the danger is much reduced, not only because the two walls are thicker than a single wall and because there is a clear line or space between the walls, but, in addition, there is a certain amount of brickwork between the ends of the beams in one building and the ends of the beams in the other building. In the case of a party wall, however, the condition is not so favorable, because the beams in one building can be placed close to the beams in the other building, not only by putting the beams end to end if the wall is wide enough to have sufficient bearing for each beam, but also by staggering the beams. In the latter case the beams of one building will be placed in the spaces between the beams of the other building, so that the ends overlap, which, in case of a fire which is not hot enough to have the heat penetrate the walls, results in the beams of the adjoining building also beginning to burn, thus carrying the fire from one building to the other. This is a very important matter from a Fire Insurance standpoint, and a rule has been adopted requiring at least 4 inches of brickwork between the ends of beams in party walls.

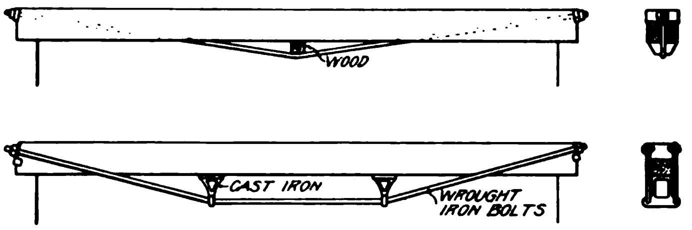

Fig. 23. Methods of Trussing Wood Girders

Beams on Stud Partitions. Except in the case of frame buildings, which are built to specifications calling for beams to rest on stud partitions, this practice is not permitted.

Beams Anchored to Walls. It is customary to anchor each tier or floor-set of beams to the walls at intervals of, say 6 feet, by the use of wrought-iron anchors. This anchor consists of a strap or plate of iron, one end of which is bolted or nailed to the side of the beam, while the other end holds in a vertical position an iron rod around which the bricks are laid. The result is that any tendency of the beam to pull out, or of the wall to fall away from the beam causes a reverse pull and thereby strengthens the uprightness of the whole building.

Beams on Girders. When beams are placed on girders, it is usual to place the butt ends of the beam together and strap them as described for anchoring, or allow them to overlap each other for a distance of, say 12 inches, and spike or bolt them together.

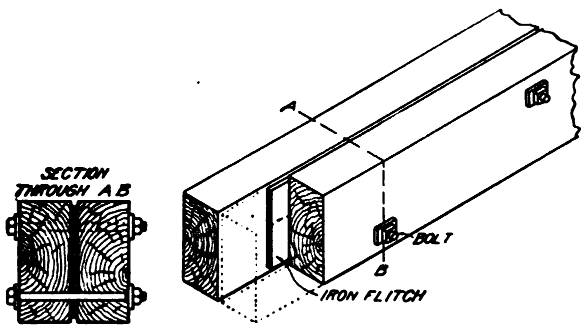

Fig. 24. Composite Girder Known as the Flitched Girder

Beam Specifications. The proper description of beams in a Fire Insurance report would give the width and depth of the beam, the width of the span, the spacing of the beams from center to center, and the kind of wood composing the beam. It should also state the presence of bridging, the distance of the bridging, the beveling of the ends—the self-releasing feature—and the anchoring of the beams to the walls.

Girders. A girder is a horizontal bearing member of larger size and dimension than a beam, and extends from wall to wall, wall to column, or column to column. It is used to support a section of the wall, usually at an opening, or to carry the floor beams.

Bearing of Girders. Girders are set either on cap stones, or, when the girders rest upon walls or piers, on cast-iron plates. When the girders rest on columns, a cap plate of iron is provided.

Girder Specifications. The proper description of girders in a Fire Insurance report would give the width and depth, width of span, the spacing, the kind of wood, and what the girder supports.

Types of Girders. Girders are made single, double or triple. *Wood* girders that are made from a single log are sometimes called single-stick members, and are often trussed as in Fig. 23, to give added strength. *Composite* girders consist of two or three timbers fastened together. A special type of girder—known as the *flitched girder*, Fig. 24—consists of two thicknesses of wood with an iron plate between, and the three pieces bolted together.

The principal office of girders is to support floor beams. When resting on walls, they are made self-releasing in the manner described for beams, and when resting on columns and coming end to end, they are strapped or fitted into each other by dove-tailing or overlapping as just described for beams.

ROOF CONSTRUCTION

Roof as a Fire Hazard. The roof or cover of a building plays a much greater part in case of fire than is generally considered. The liability of a wooden roof or cornice taking fire from an adjoining or nearby burning building is very evident, and such a roof is a standing invitation to fire to enter a building.

As against this outside exposure to fire, there is to be considered the danger inside the building. In this case, the firemen are assisted or handicapped according as they can or cannot readily cut through the roof to let out the smoke and heat, an operation which firemen call *opening up* a building, and which is one of the most important in the work of putting out a fire, as it decides to a great extent the ability of the firemen to take hose lines close to a fire.

In this particular the tin roof, all things considered, is probably the best, for, when necessary, the firemen can easily chop holes in it or cut it up, and yet it offers quite as much protection against brands or sparks as the earthern roofs and without having the objection of their greater weight. The tin roof is also preferable to the slag, gravel, or composition roofs, for these have been known to make serious fires in themselves, frequently worse than the fire inside the building, and, in some cases, have been responsible for extra fire alarms being turned in.

A study of roofs, from a Fire Insurance standpoint, should include the framing or supporting part of a roof, the covering or outside surface, the various types of roofs, the structures built upon, or resting upon roofs, the roof space, and the cornice.

Flat Roof. From a construction standpoint, a flat roof is simply another floor of the building, and like other floors, consists of the supporting beams, and the boarding which is placed on these beams. Furthermore, as a roof must be weatherproof, it is customary to cover the roof boards with some water-proof material, and provide the proper drainage so that the water will not collect in pools on the roof.

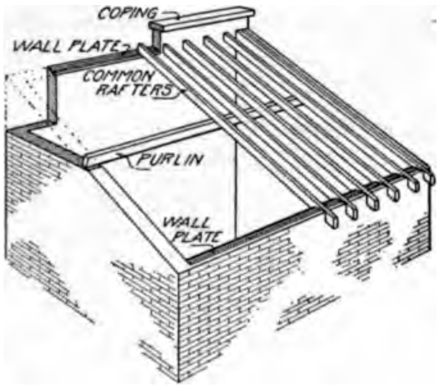

Fig. 25. A Lean-to Form of Roof

In order to drain a roof, it is necessary to give it a *pitch, i. e.,* put the roof surface on an angle; but as the ceiling of the top floor should be level like the ceilings of the other floors, the roof must of necessity be built up to a varying height according to the amount of pitch in order to accomplish this end. The result is that the distance between the ceiling of the top floor and the outside boards of the roof will be a matter of several feet and this extra height represents what is called *roof space, blind attic, cock loft,* or *hanging ceiling.* It is especially important from a Fire Insurance standpoint, because if fire once enters, it spreads throughout the en-

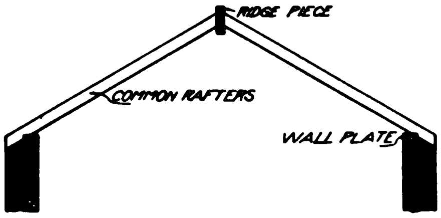

Fig. 26. Double-Slope Pitched Roof

tire extent of the roof space and is particularly difficult for the firemen to extinguish.

Pitched or Steep Roof. The simplest kind of a pitched or sloping roof is the lean-to roof, Fig. 25, which is made by carrying one wall sufficiently higher than the other to give the required slope.

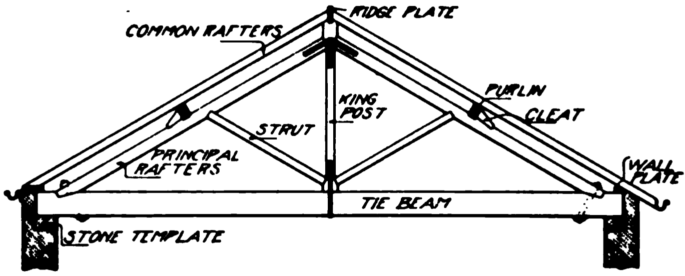

Fig. 27. King-Post Truss

The most common form of pitched or sloping roof is one that slopes both ways, Fig. 26, the highest part being called the *ridge* and the horizontal piece of timber forming the ridge being called the *ridge piece* or *ridge tree*. The timbers, which are placed in the directions of the slope of the roof, are called *rafters*. The double pitch roof is given some variety of form by using several slopes or variations of pitch. The roof is ornamented still further by means of gables or dormer windows, the latter consisting of covered openings projecting from the roof proper.

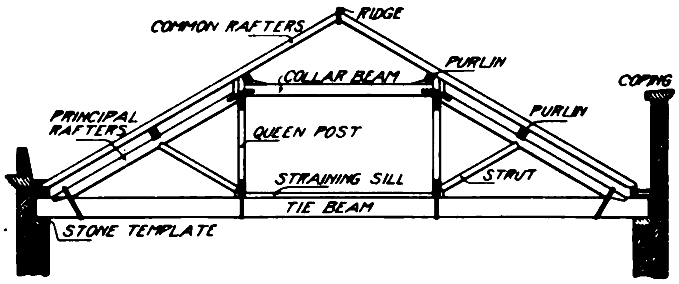

Fig. 28. Queen-Post Truss

Roof Trusses. In the case of roofs of short span, the rafters have no ties and are supported by resting on the wall, and by being nailed to the ridge piece.

In the case of roofs of wide span, it is usual to use a framing known as a *truss*. One type of roof truss called the *King-post* truss, Fig. 27, receives its name from the central upright, which is called the King-post. Its horizontal member is called the *tie-beam*, while the sloping members are called *rafters*, and the members running from the joint of the tie-beam and the King-post to the rafters are called *struts*.

Another type of truss called the *Queen-post* truss, Fig. 28, receives its name from the upright members called Queen-posts. Its structural members are practically the same as those of the King-post truss, except for the horizontal member which is called the *collar beam*.

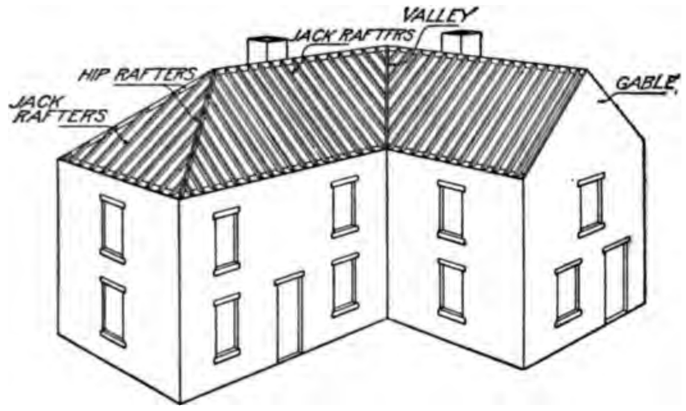

Fig. 29. Diagram of Hip of Roof

The *hip* of a roof is an angle made when a building, instead of having a gable, has the roof returned around the end of the building, Fig. 29.

A *valley* is formed when two roof surfaces meet together and form an internal angle.

The *eaves* or the *cornice* of a building is where the roof connects with the walls. They usually project to a greater or less extent so as to carry off the rain-water through spouts leading to the ground. A cornice is really an ornamental finish for the eaves.

The *flashings* of a roof are the strips of metal fastened at the base of all chimneys and other openings or projections in a roof including parapet walls to prevent the possibility of leaks at these points. They are bent upward against the vertical part of the projection, are brought down under the roof covering, and nailed to the roof boards. Another piece of metal called the center flashing is secured and brought down over the roofing.

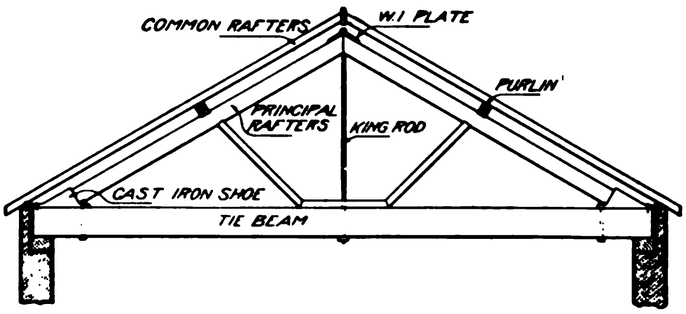

Fig. 30. Iron and Wood Truss with Wood Tie-Beam

Roof trusses are often constructed of a combination of wood and iron, the iron members in such cases being those in tension; iron rods are substituted for the wooden tie-beams and King-posts, Figs. 30 and 31. Iron trusses are extensively used in place of wooden trusses for carrying the roofs of such buildings as warehouses, sheds, workshops, railroad stations, etc., where open roofs are preferable to ceiled roofs. Trusses of this kind shown in outline in Fig. 32 consist largely of wrought iron or steel, although cast iron is fre-

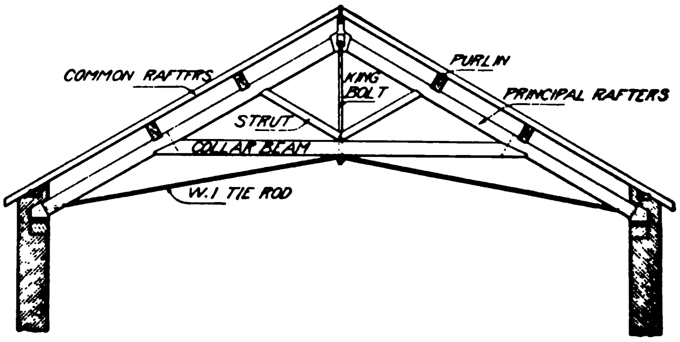

Fig. 31. Iron and Wood Truss with Iron Tie-Rod

quently employed for struts and connections. In the construction of iron roof trusses, the most suitable form for the principal rafters is the T iron; for the struts, angle iron, channel iron, flat bar iron, or cross iron may be used, Fig. 33.

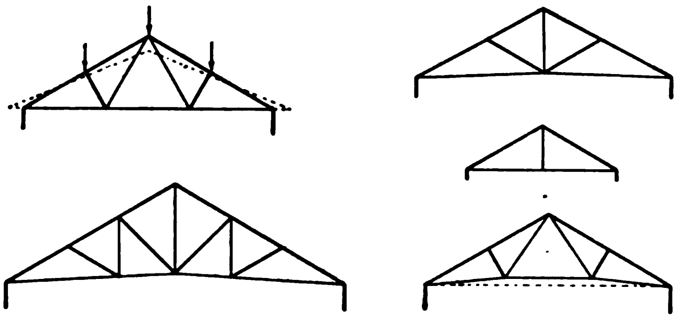

Fig. 32. Diagrams of Truss Forms

Mansard Roofs. A roof of special Fire Insurance importance is called the *Mansard roof.* This could properly be called a Mansard floor, because it is in reality an additional floor built on top of the building. When it is considered that Mansard construction is always frame, this becomes important in connection with buildings which, in all other respects, might be considered *brick* buildings. In other words, it is a frame floor on top of a brick building.

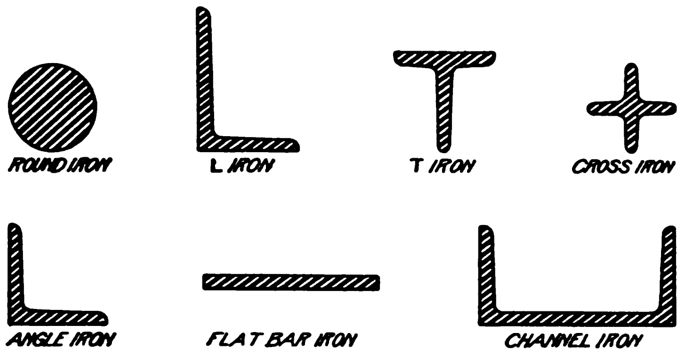

Fig. 33. Sectional Forms of Structural Iron

In a similar way, dormer windows, gable windows, or roofs which have a high peak or gable are noteworthy from a Fire Insurance standpoint, when they are of frame construction and placed on top of brick buildings.

Roof Structure. Roof structure is the general term applied to an addition to the roof of a building, such as a cupola, a tower, a steeple, or enclosures of various kinds. They are practically separate rooms in themselves. A *bulkhead* is a special term given to the extension of a shaft, when it is carried through and above the roof. Its purpose is to make the shaft form a good outlet, more particularly for fire purposes; smoke, heat, and flames can pass up through the shaft and into the open air rather than be stopped or held down by the roof, in which latter case the fire must spread out horizontally, and then work downward through the building. Bulkheads are also used for the ordinary purposes of a building in order to give easy access to the roof.

Cornice. The cornice of a building is also of Fire Insurance importance, when it is of wood construction, because it represents an additional amount of burnable lumber, particularly if it is continuous with the cornice of adjoining buildings or open to, or connected with them in such a way as to favor the easy passage of fire from one building to another. If the cornice is of metal, and is open to the roof space of the building, it is also objectionable as it is a means of spreading fire.

Cornices are usually placed in position only at the front or street sides of a building, as their purpose is chiefly ornamental, unless they also act as a gutter to assist in draining the roof. Cornices are built of wood, brick, metal, or stone, are either open or boxed, and are separate or continuous with other buildings. A fire-resistant cornice should be built of fire-resistant material and secured to the walls without the use of any woodwork. The best type of cornice is of brick built above the roof level like a parapet wall.

Lightning-Proof Roof. The story of fire losses everywhere has for years proved the tremendous importance of having the roofing of fireproof quality to prevent the spread of the conflagration; in fact, within the "fire limits" of all cities, only fireproof roofs are allowed. An added advantage possessed by metallic roofing in common with clay, tiles, slate, etc., is that of being *lightning-proof*. The case of a metal-covered building or its occupants or contents being struck by lightning, is practically unknown. The broad

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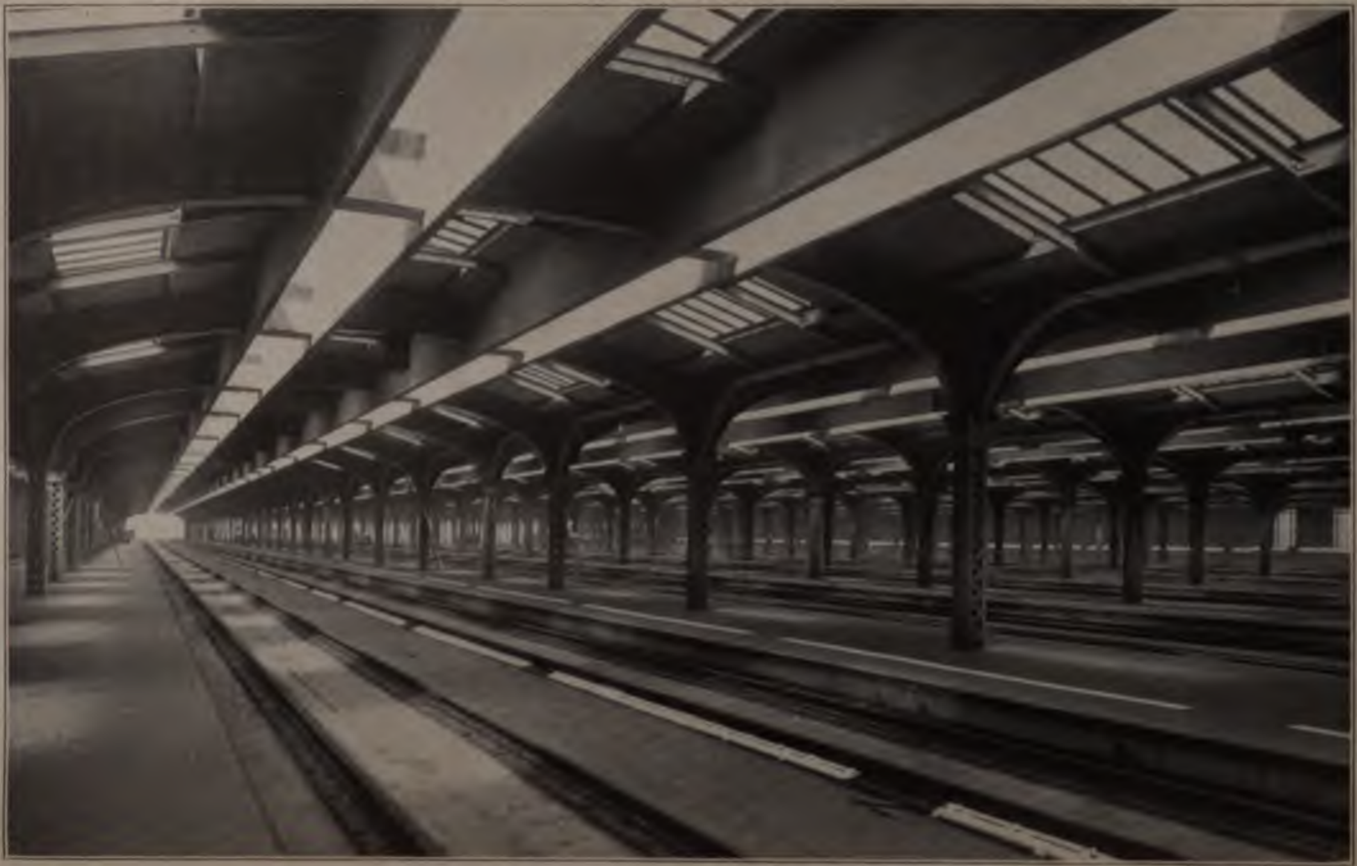

BUSH PATENT TRAIN SHEDS, CHICAGO AND NORTHWESTERN RAILWAY DEPOT

Construction Is Entirely of Steel and Concrete. Smoke Stacks of the Engines Follow the Slits in the Roof, and Thus Avoid Filling the Train Shed with Their Smoke

Charles S. Frost, Chicago, Architect. George A. Fuller Company, Contractor expanse of the metal covering and its many metallic connections with the earth offers such a low resistance to the enormous charge that it is easily and safely led to the ground; hence, the safety of a metallic roof over all others—an important advantage.

ROOFING MATERIALS

Roofing materials may be classified broadly as follows: (1) wood shingles; (2) composition (coal-tar and felt paper); (3) gravel (slag); (4) terra cotta (clay tiles); (5) slate shingles; (6) cement (pavements);* (7) tin or copper tiles or shingles; (8) corrugated iron; (9) sheet copper; and (10) roofing tin (terne plates).

Non-Metallic Roofings. *Wooden Shingles.* Wooden shingles are forbidden in many cities on account of the fire hazard and hence are generally used in isolated positions, notably for detached country houses. Even for this purpose their value is decreasing, for it is now almost impossible to procure the old-fashioned heart cypress shingles, the present supply being made of soft wood largely gotten from saplings and limbs, which easily split, warp, and blow off. They are, therefore, deficient in endurance, costly in that they frequently need repairs, and they lack stormproof qualities.

Slag, Gravel, and Composition. Slag, gravel, and composition are all composed of pitch or tar and dry felt as a base. They catch fire easily and burn with an almost unquenchable flame, thus making the fire hazard with this class of roofing about the worst possible. Furthermore, coal-tar products contain volatile substances which oxidize and evaporate under ordinary temperatures, leaving the felt hard and brittle, and subject to rapid disintegration. Manufacturers of these roofings not only advise a double coating when first laid, but recommend re-coating every three years. All flashings, valleys, gutters, etc., are of metal.

Terra Cotta and Slate Shingles. Terra cotta and slate shingles are used for cheap roofs only, and for that reason are of limited utility. As they crack and fall off under the heat, they are objectionable on the fire hazard score; their weight demands a very rigid support; and they are difficult and costly to lay.

Cement. The use of cement roofing is practically confined to flat coverings of the great modern fireproof city buildings, and, therefore, really constitute pavements in mid-air. Metallic flashings are invariably employed.

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*Metal flashings, valleys, hips, gutters, etc., are always used with the preceding materials.

Metallic Roofings. *Tin or Copper Tiles or Shingles.* Tin or copper tiles or shingles are in use to a limited extent.

Corrugated Iron. Corrugated and V-crimped galvanized iron is used for skeleton-iron factory buildings and sheds, outbuildings, etc., with a pitch of not less than 3 inches. Galvanized iron sheets are now as staple as steel rails.

Sheet Copper. Copper is undoubtedly the best metallic covering, but its use is limited because of the cost of the metal and the cost of the expert workmen required to lay a copper roof of flat sheets so that the seams may hold, and so that the proper allowance shall be made for the great expansion and contraction of this metal. All sheet copper is necessarily pure metal.

Roofing Tin. Tin roofing is the next best material to copper, and, all things considered, is the standard for every roofing purpose. Tin may be laid on a roof of any shape or size, and well-made tin, properly put on the roof and painted, lasts well, is light, safe, and easy to repair.

The production of tin plate had its earliest and greatest development in Wales, about 200 years ago. This country began to produce its own supply, in 1890, and now, with the exception of some special grades and sizes, makes all it consumes and more. Wales, however, is still the main source of supply for the rest of the world.

Tin plate consists of a relatively strong and inexpensive sheet of black metal, protected by a coating of dearer and better metal of a lower melting temperature, which oxidizes less rapidly and, therefore, lasts longer under exposure. Tin plate today consists of sheet steel, either Bessemer or open-hearth, dipped in pure tin—*bright tin plate*—or in a mixture of tin and lead—*terne* or *roofing plates*.

Tin and terne plates are distinguished according to their size, weight, and thickness of coating. The sheets are made in standard sizes, such as 10×14, 14×20, 20×20 inches, and other sizes. A fixed number of sheets come in a box, the weight of which varies according to the thickness of the sheets, which is determined according to established rules in use by the manufacturers. For example, the sheets are known by their weight per box and size of sheet, that is, 80 pounds, etc., up to 100 pounds, and then by the use of letters, such as IC, IXL, IX, IXX, etc. Each combination of letters indicates a certain number of pounds; for instance, IC equals 107 pounds; IXL equals 128 pounds; IX, 135 pounds, etc.

Besides the matter of size, there are other distinguishing characteristics such as thickness of the steel base sheet—called "the substance"—the process of applying the coating, and the thickness and evenness of coating (amount of terne mixture used); these last two points are covered by the "brand" according to the custom of the trade.

For all good grades of tin, the basic sheets are first re-squared—that is, cut perfectly square so that they will align and lie perfectly straight in the roofing construction. They are now "pickled," so as to be cleansed of all dirt and oxide produced in the rolling process, and after being washed in clean water, are ready for the coating; this is composed of a mixture of pure tin and lead—the most durable metals against weather exposure that can thus be employed. All makers follow the same practice up to this point, the wide differences in manufacturing methods occurring in the *process of coating*, and the *amount and evenness of coating.*

The *cheapest* process today is to dip the basic sheet, "pickled" and washed as above described, into a bath of acid flux to make the coating adhere. The acid flux universally employed in this process is *muriate of zinc*, which is quite inexpensive; however, no matter how heavy the coating, a residue of the acid flux always remains in the pores of the basic steel sheet, thus corroding and destroying it earlier than necessary—a prime cause of much roofing tin failing to last as long as it should.

In the *best* process, the cleansed sheets are boiled in *pure palm oil*, which is imported from the eastern coast of Africa in original cases. The experience gained in the art in Wales for years has shown conclusively that pure palm oil is the very best *alkaline flux* for this purpose. By its use an *alkaline* residue is left in the pores of the underlying steel sheet, which helps to *preserve* it, not disintegrate and destroy it as when acid flux is used. In the *palm oil* process the original boiling and subsequent dipping or coating *must* all be done by hand, and this, in addition to the cost of the palm oil and the relatively expensive workmanship, makes the coat of the tin plate greater, but at the same time increases its durability.

It is impossible to determine by the eye or any known tests, whether or not a plate has been coated by the *acid* or *palm oil* process, and in this respect the chances for deception are apparent. A plate made by either process can be finished with a dry or greasy surface.

Terne coating is a ductile alloy and is applied to the basic steel sheet by dipping in a molten bath—forming at best a thin film which usually attaches with no greater force than gravity. As the finished plate cools, the two component parts—sheet steel and coating—contract at different rates, producing minute openings in the *thin* coating, a feature which it is impossible entirely to avoid, no matter how thickly the coating is applied. In the manufacture of the best plates, however, these minute holes are to a large extent filled up by *compacting* the ductile coating at the last step in the process. The sheets are dipped once, twice, or several times, as may be necessary to gain the desired coating.

After the plates are coated, they are cleansed with bran and sheep-skins, and then taken to the assorting room, where those which are unfit for roofing purposes—known as "wasters"—are excluded from the *prime* or perfect sheets. Only the primes are stamped with the *brand* and *thickness* IC or IX. These two classes differ only in the thickness of the black plate, the coating for any given brand being the same. The net weight of a box of common IC, 20×28 inch plates, 112 sheets, is 214 to 216 pounds; and of IX, 20×28 inch, 112 sheets, 270 pounds, (without the wooden box). Extra heavy coated plates weigh more on account of the increased weight of coating. It does not necessarily follow, however, that a box of IC 20×28 inch, weighing 230 or 240 pounds, contains additional coating, because the black plate may have been rolled of a heavier gauge than ordinarily used, thus adding many pounds to a box.

PARTITIONS

The partitions of a building serve to divide a floor or horizontal section of a building into rooms, sections, offices, or other parts. They are sometimes spoken of as walls and this is permissible, when

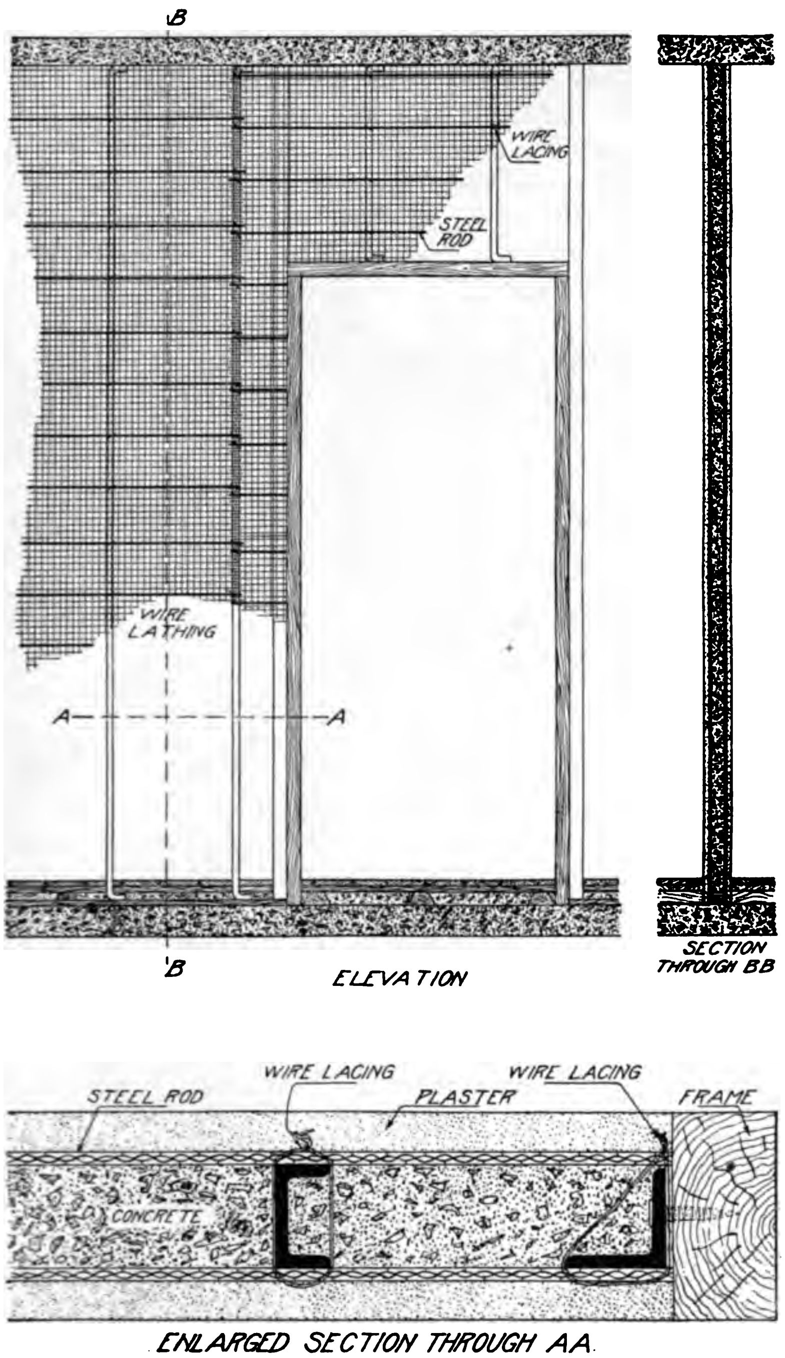


Fig. 34. Elevation and Section of Metal Lath-and-Plaster Partition

used to designate the enclosures of a room, but for Fire Insurance purposes it is much better to reserve the term *wall* for the outside walls and for interior walls which divide a building in a large way, particularly from the basement to the roof. To avoid misunderstanding the term "partition wall" may be used.

Lath and Plaster. Partition walls in a frame or ordinary building are usually spoken of as lath-and-plaster partitions or stud partitions. These are constructed of wood studs which are set vertically between the top and bottom timbers, called plates, and which are provided with horizontal bridging; on the studs will be nailed the wood laths, which act as a key or hold for the plaster. This is called a *wood lath-and-plaster stud partition.* In place of the wood laths, metal laths may be used, in which case the partition will be termed a *metal lath-and-plaster partition*, Fig. 34. When plaster boards are used in place of the metal laths, the partition will be termed a *plaster board partition.*

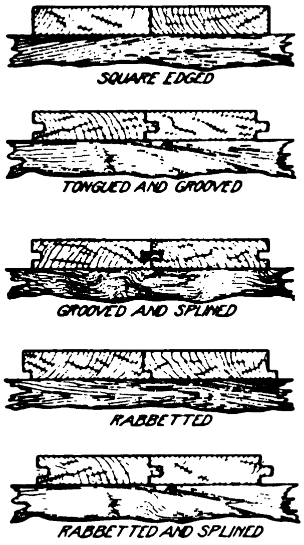


Fig. 35. Standard Forms of Flooring

Frame. A frame partition may consist of wood studs with boards nailed on the studs, or simply of the boards set up and cleated or nailed at the top and bottom.

Plank. A plank partition is a wood partition made of boards which are sufficiently thick to be considered a plank rather than a board, that is, 2 or more inches thick.

Partitions will sometimes be found which are built of wood studs covered with tin, corrugated iron, galvanized iron, or other form of sheet metal.

FLOORING

A clear distinction should be made between the flooring and the floors of a building.

A *floor* is really a horizontal division of a building with respect to its construction; *i. e.*, a floor, from a construction standpoint, includes the beams, the floor boards, and the ceiling. By the *flooring* is meant the floor boards which are laid on top of the wood beams in order to make a level surface and a convenient bearing and footing.

A great variety of materials is used for the flooring of a building, a partial list of which is as follows: *Wood, cement, concrete, brick, stone, earth, asphalt, tile, mosaic,* and *granolithic.*

Wood flooring is laid single, double, or even triple. Ordinary wood floor boards are ⅞ inch or 1 inch thick and fit into each other by what is called *tongue and groove,* Fig. 35.

Plank flooring comes 2 inches, 3 inches, or 4 inches thick, and the boards are fitted together by having a groove in each edge of the plank and by driving into the space between the two boards made by the grooves, a thin stick of wood called a spline, Fig. 35. A special type of wood flooring used for decorative purposes is the parquet or hardwood flooring which is usually made in squares and is laid on rough floor boards.

The various kinds of mineral floor surfaces are in use principally for their waterproofing qualities, and are so generally known that no special description is necessary. An important point about flooring from a Fire Insurance standpoint is the presence of some material between the floor boards for fireproofing purposes, Fig. 36. The materials used are felt, asbestos, mineral wool, cork, tin, sheet iron, and waterproof paper.

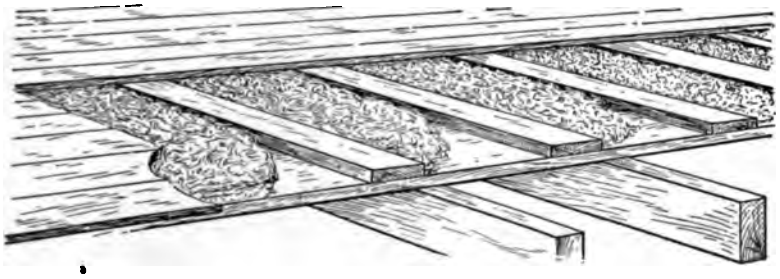


Fig. 36. Floor with Fireproof Packing Between Layers

FINISH

Fire Insurance is interested in the finish of a building, insofar as this affects the spread of fire, particularly in the use of materials for covering partitions, ceilings, and the inside surface of brick walls.

There are a number of other kinds of finish such as, stucco, staff, scagliola, and imitation marble, which are used for ornamental purposes but from a Fire Insurance standpoint may be treated as ordinary plaster or other covering.

BUILDING OR HOUSE TRIM

This is a general term used to describe the smaller features of a building such as doors and door frames or boxes, window frames and window casings, mantels, wainscoting, base-boards, chair rails, picture molding, shelving, cupboards, and closets.

The Fire Insurance interest in house trim rests in the fact that, when of wood, it represents an addition to the amount of combustible material in the building construction, or may represent almost the only combustible material in what is otherwise fire-resistant or semi-resistant construction.

In a recent development of fire-resistant materials, wood house trim has been treated by chemical or electrical processes, which have for their object the making of the wood fire-resistant or fireproof. Another development is the displacing of wood as a material for house trim and the use of sheet metal in its place.

FLOOR OPENINGS

What Fire Insurance calls the floor openings of a building constitute a most important feature in building construction. In nine cases out of ten, when a fire has started and obtained headway, the question whether the fire will extend throughout the building depends on the floor openings. They are easily the most dangerous structural feature in a building when improperly installed, and in a study of Fire Insurance too much attention cannot be given to them.

Definitions. In a general way a *floor opening* is described as any vertical opening in a building, *i. e.*, any hole or break in the horizontal or floor construction. The floor openings are the vertical openings of a building just as the windows and doors are the horizontal openings. A vertical opening may or may not be a shaft, or represent a shaft, the latter in general meaning a continuous or enclosed opening such as, for example, the entrance and passageway to a subterranean mine, or the entrance and passageway to any spot underneath the earth. A *shaft* may be defined as a continuous and enclosed hole or opening running in a vertical direction. In a way, the shaft might comprise the hole or opening as well as the enclosing or surrounding walls, but, as a matter of fact, in its narrow and restricted meaning, the term has come to be applied to the enclosing walls only; that is to say, a brick shaft means enclosing walls of brick; a frame or wood shaft, enclosing walls of wood, etc.

In studying floor openings, it is important to grasp the distinction between an opening as such and the use that is made of the opening or the machinery or other things that are within the opening. In the case of an elevator shaft, the car running up and down the opening is the elevator, while the opening is the elevator shaft or elevator well. In the same way the stairway is the opening or shaft in which the staircase or stairs are placed.

Another point that will prove of considerable value in the practical work of Fire Insurance inspection is to distinguish between the walls of the shaft, the openings in the walls, and the cut-offs or materials that are used to close or shut up these openings.

In Fire Insurance floor openings or the shafts of floor openings are generally classified as fire-resistant or non-fire-resistant.

Fire-Resistant. *Standard.* A standard floor opening or shaft is one whose walls are of brick and which extend from the basement to and above the roof with a bulkhead at the roof.

Miscellaneous. Other shafts constructed of incombustible or fire-resistant materials are those built of hollow tile or terra cotta, plaster blocks, cinder blocks, metal lath, cement or plaster on metal lath, and iron studs, concrete, sheet metal, or corrugated iron on iron frame.

Non-Fire-Resistant. Ordinary or non-fire-resistant shafts include the following: Wood covering or sheathing on wood or iron framework; metal sheathing on wood framework; wood, with glass or plaster on wood lath.

An *open* shaft is the term applied to a floor opening that is without shaft walls or enclosing walls.

Some floor openings have an enclosure that is not strictly considered a shaft. For example, (1) the lath-and-plaster hallway enclosure for stairways in the ordinary dwelling-house; (2) the stairway enclosed by a board partition, which is placed at some distance from the stairs proper in order to allow a landing at each floor—generally known in Fire Insurance practice as a *frame-enclosed stairway;* (3) the stairway that is enclosed with boards close to the line of the stairs and which has the landings on the loft or floor proper—generally known in Fire Insurance practice as a ***boxed stairway.*** In other words, each flight of stairs is really in a separate box of its own, and there is no continuous connection from one flight to another flight. In order to pass from one floor to another a person has to enter the boxing and then pass out of this same boxing to reach another floor. The boxing of the stairway is sometimes carried out only on alternate floors, Fig. 39.

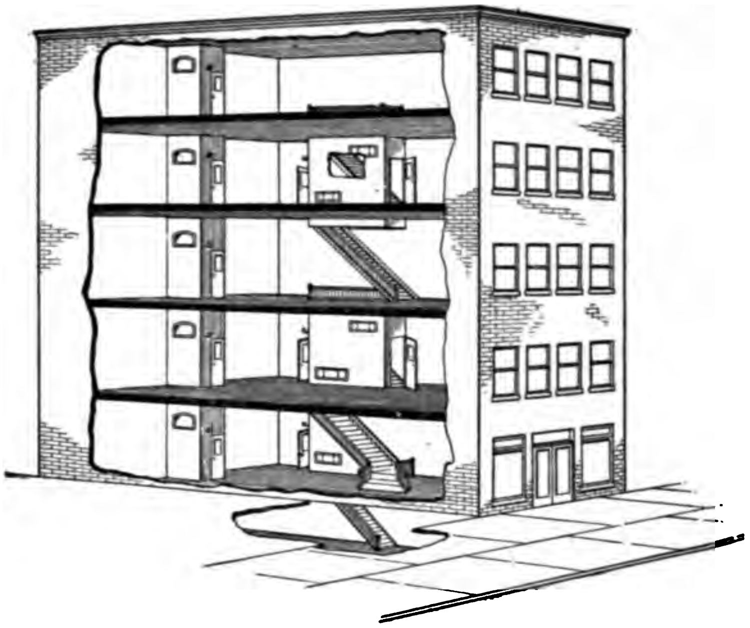


Fig. 39. Diagram Showing Method of Boxing Stairways

Stairway. The construction of a stairway from a Fire Insurance standpoint includes the opening for the stairs, the shaft or enclosing walls, and the stairs proper. The term ***staircase*** is used to describe all the flights or runs of stairs, from top to bottom, while a flight is the portion of the staircase extending from one floor to another floor or from floor landing to floor landing. The ***strings*** are the side framework which supports the treads and the risers. The *treads* are the steps. The *risers* are the upright pieces which are placed at the rear end of the treads, to help support them. *Landings* are the places where the stairs adjoin the floor levels or where a flight or run of stairs is broken in two, either to make a turn or to shorten the continuous run of stairs.

Wood stairs have wood strings, treads, risers, and landings.

Iron stairs are those which have iron strings, treads, risers, and landings. In some cases stone, slate, or marble will be substituted on the treads and landings.

Stairs may be described or classified as follows: *Circular stairs*, or those where the stairs wind around a center post; *straight stairs*, or those where the flight or run is straight and continuous from floor to floor; *return stairs*, or those where the flights are broken and continued parallel to each other; and *winding stairs*, or those where the stairway bends from a straight line. When the landing places are not on a single level, but consist of a number of steps which conform to the angle of the turn, these particular steps are known as *winders*. Special attention is called to these because the New York Building Code prohibits them in stairways in theaters and because they are for that matter a bad feature in any stairway.

The construction features of a stairway from a Fire Insurance standpoint may be summarized as follows:

(1) The floors or floor construction pierced by the stairway, whether it goes through the roof and has a bulkhead or simply a scuttle opening.

(2) Material of the stairs, particularly the treads and landings; and if stone, whether supported underneath with metal plates.

(3) Materials of the shaft or enclosing walls; the openings in the walls, and how they are closed or cut off, giving the material of the cut-offs and their operation, if automatic.

(4) If the runs or the flights of the stairs are not enclosed, whether there is some kind of a cut-off at the floor level; that is, a door at the bottom or top of each flight or a trap door that covers the stairway opening at the floor level, and if the trap is hand closed or automatically closed.

(5) If the stairway is in the same shaft or opening with other stairways or floor openings; whether it adjoins, or is within fifteen feet.

Elevators. Elevators from a Fire Insurance standpoint may be treated along the same lines as floor openings in general except for a few special points. The car or elevator proper which carries passengers or freight is operated by machinery, which is usually

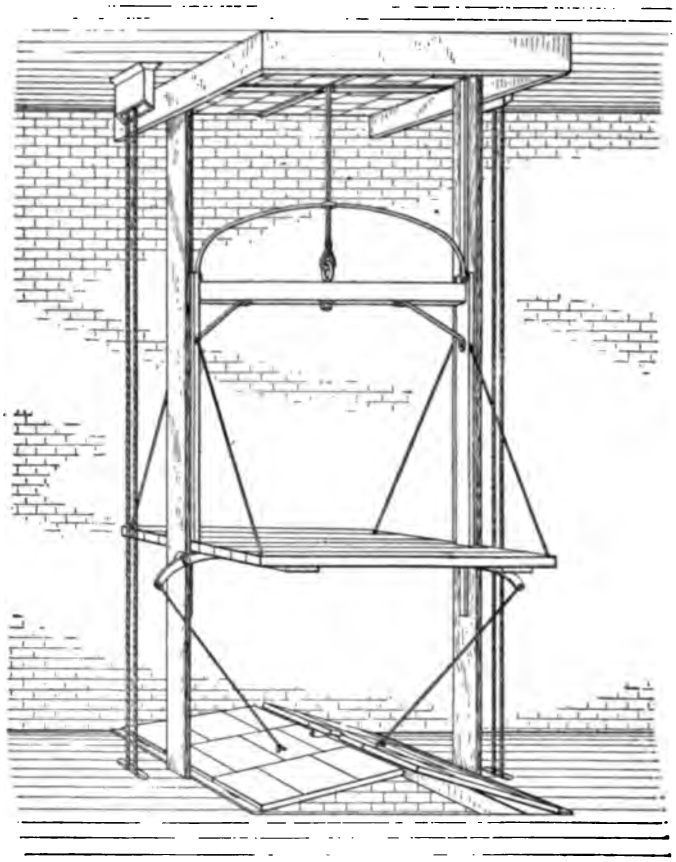


Fig. 40. Drop Floor Cover for Elevator

located in the basement of the building, close to the elevator shaft—sometimes directly under the elevator shaft or adjoining it. In either case there is an opening in the elevator shaft to permit the cable, which supports the car, to pass from the motor or engine into the shaft. The presence of this opening provides an opportunity for fire originating in the motor or engine room to extend into the elevator shaft and thence throughout the building. For this reason the cable opening deserves attention. The dimensions of the opening and any effort made to close it with an apron or drop-cover should be examined, Fig. 40.

The machinery which operates the elevator may be treated under the subject of heat, light, and power of the building, although where it is desired, it can be described with the elevator. The occupancy of motor or engine rooms in connection with elevators is subject to the same conditions as other occupancies. One fact that deserves particular attention is the use of the bottom of an elevator as a closet or storeroom, which is decidedly objectionable, because of the combustible and inflammable materials that are collected there. The side posts or guides for the elevator car and the balance weights are frequently made of wood or have wood boxing and as they become saturated with oil they represent a fire danger.

The elevator shaft will also be used as a place for running conduits or channels for piping and electric wires. Where this is done, the construction should be examined, because it may represent a combustible feature in a shaft that otherwise might be designed and constructed to be fire-resistant.

Dumbwaiter. The construction of dumbwaiters may be studied along the same lines as elevators, because the two are practically identical from a Fire Insurance standpoint, the dumbwaiter being virtually a small-sized elevator. Dumbwaiters, as a rule, are worked by hand, though in some cases power such as electric motors is used. The principles of construction applying to floor openings will, in general, hold good for dumbwaiters.

Hoists and Hatchways. This type of floor opening usually involves very little construction, because it is simply a square hole in the floor construction, through which bundles or cars may be raised or lowered. In most cases, it represents a forerunner of the modern elevator; where they are enclosed, the principles of construction which apply to the shaft or enclosure of floor openings, will, in general, also apply to them.

Light, Ventilating, and Air Shafts. The construction of light, ventilating, and air shafts—which, by the way, do not include exterior courts, *i. e.*, courts opening to the air—may follow the principles of construction used for shafts or enclosing walls of floor openings in general. These floor openings are practically identical with stair shafts, elevator shafts, and dumbwaiter shafts, except that the opening is used simply as an air passage instead of a passage for stairs, elevator cars, or dumbwaiter cars.

One particular feature connected with these floor openings is the use of fixed shutters or louvres, which are placed at the window openings between toilet rooms and the shaft. *Louvres*, Fig. 41, consist of thin slats fixed at an angle into a frame which is attached to the walls of the shaft; the slats and frame are made either of wood or metal. If the louvres are made of metal, the method of attaching them to the frame and the method of attaching the frame to the shaft walls should be examined. The two general methods of doing this are by riveting and by soldering. The use of solder is objectionable from a Fire Insurance standpoint, because in the case of fire, the heat melts the solder and the louvre falls apart, thereby giving a clear opening for the fire to pass through; on the other hand, in the case of riveted louvres, they will hold their place practically up to the melting point of the metal.

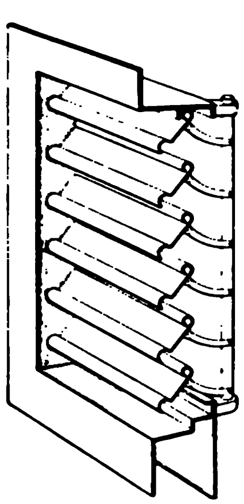
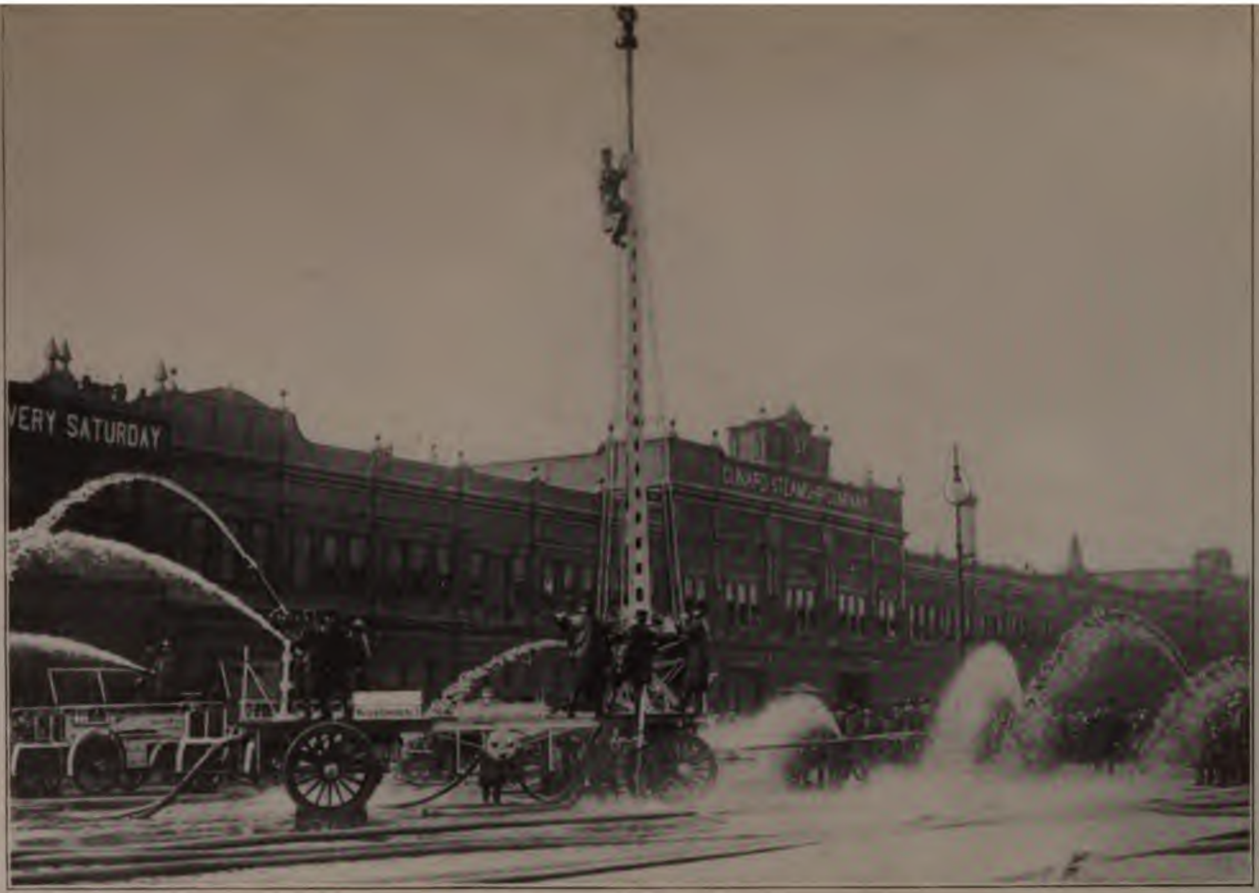


Fig. 41. Louvres

Vent Flues. The construction of vent flues or ducts for carrying off foul air is practically identical with the larger types of light, ventilating, and air shafts just described. Usually they are not sufficiently large to be made into a shaft, but are run into, or close to, walls.

Channels, Chases, and Ducts. The class of floor openings called channels, chases, and ducts for pipes or wires are usually of small dimensions and are in many cases made by recessing or cutting out a portion of a wall. The construction feature to be examined is the depth of the opening in relation to the depth or thickness of the wall in which they are run, because of the danger of making a wall so thin that it loses its value either as a bearing member or as a stop to fire from an adjoining building. Such openings should not be permitted in piers, or in walls, beyond one-third the



GETTING READY FOR HIGH PRESSURE TEST, NEW YORK CITY FIRE DEPARTMENT

depth of the wall.[1] Because of their comparative concealment and the fact that they frequently extend from the bottom to the top of the building, these floor openings represent a dangerous fire passage, and should, therefore, be fire-stopped or filled in at each floor level to the extent of at least one foot. Another construction feature of notice is the material and method of covering the outside surface.

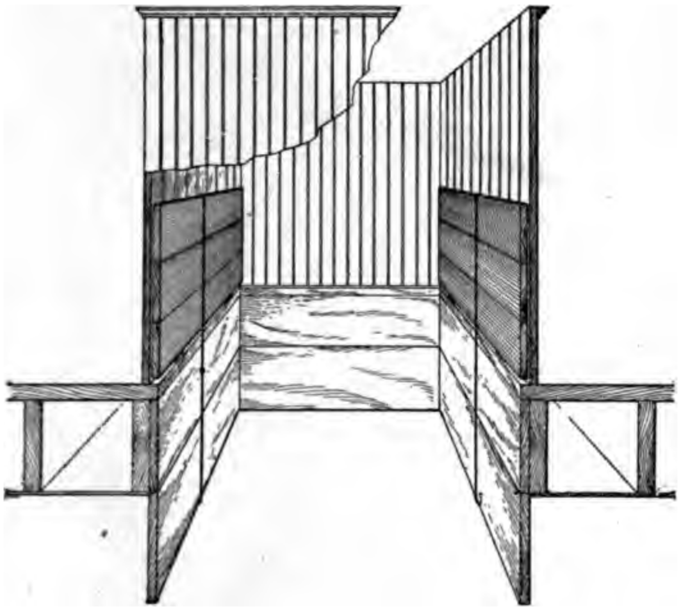


Fig. 42. Chute with Trap Cut-Off

Belt or Shaft Holes. Belt or shaft holes through floors represent an opening that cannot be cut off or stopped, because of the nature of their use and purpose. As the belt or shaft must be in continuous motion, the only thing that can be done is to make the opening as small as possible and provide a boxing or curbing at the floor level.

Chutes. Chutes are very much like dumbwaiters except that they are usually constructed at an angle. The construction features represent the boxing or enclosing of the chute, the use of metal or wood for this purpose, and the installation of a trap or cut-off, Fig. 42.

Runways. Runways are a special type of floor opening found almost exclusively in stables; in fact, these might be called horse stairways, because their function is to permit horses to pass from one floor to another. They are usually constructed at a long angle, and the construction features deal with the materials used for en-

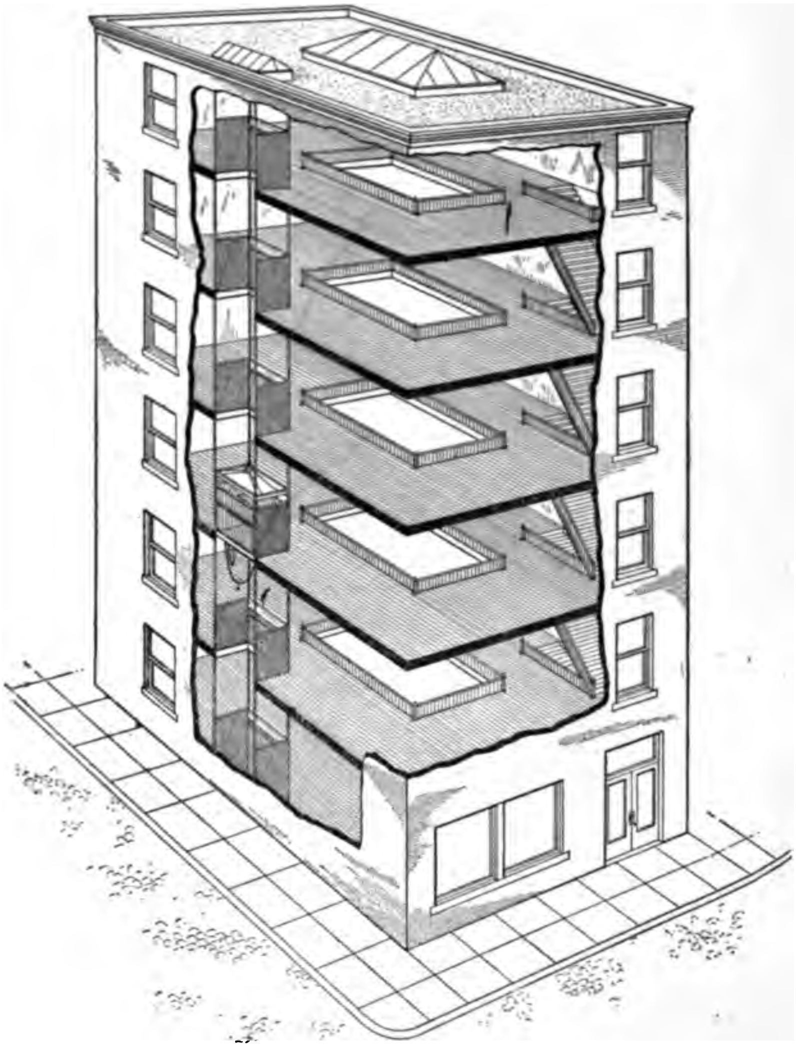


Fig. 43. Diagram of Building with Open Wellhole

closing the runway and the presence of doors or cut-offs where these can be installed.

Wellhole. A wellhole is a particular form of light shaft placed in many old-style buildings and even today found in some of the large department stores. There is no construction of particular notice, because the wellhole is usually nothing but a great big opening throughout the building, Fig. 43, and rarely enclosed or cut off in any manner. If any enclosing is done, the principles of construction covering the shaft or enclosure of floor openings in general will apply, Fig. 44.

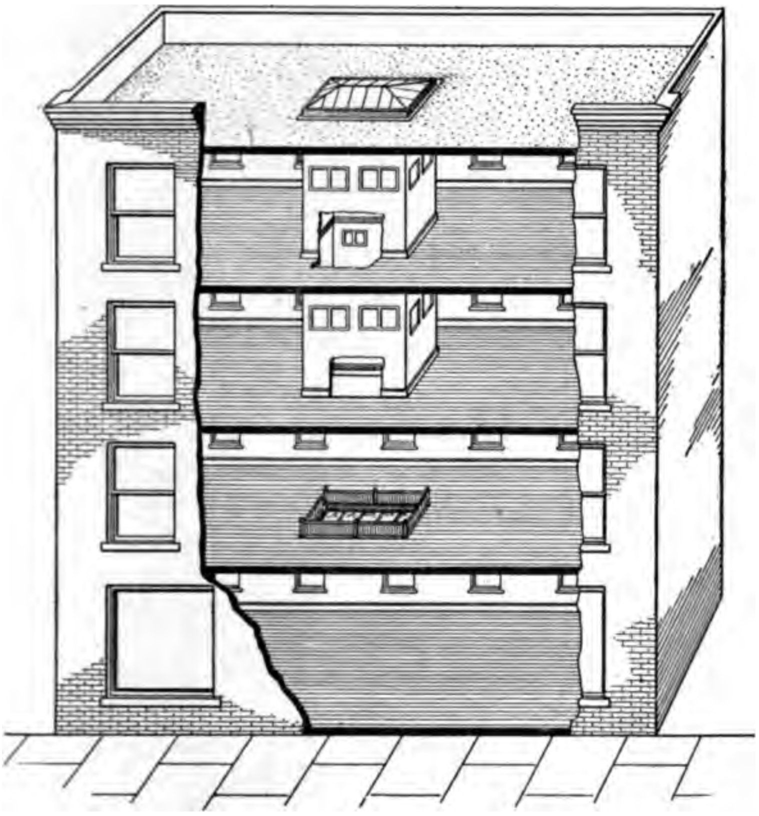


Fig. 44. Diagram of Building with Partly Closed Wellhole

Floor Lights. These are not, strictly speaking, floor openings, because they do not represent holes or openings in the floor con-

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struction, but inasmuch as they are usually constructed of glass, the strong likelihood is that in case of fire they will become floor openings, thus making it proper to refer to them here. The construction features are the thickness and kind of glass, the frame or setting upon which the glass is placed, and the dimensions of the opening.

WALL OPENINGS

The detailed construction of such minor features of a building as doors, windows, traps, etc., frequently becomes of importance in Fire Insurance. In many cases they are the cut-offs or fire-stops, and if not properly constructed, they are the weak spot in what is otherwise a substantial fire-resistant construction. It is necessary, therefore, for inspection and rating purposes, to give careful details of the methods of their construction and operation and the materials used.

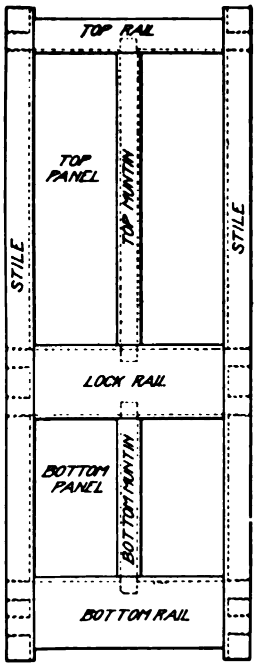

Fig. 45. Frame Door

Doors. The space occupied or closed up by a door is called the *doorway,* the sides of the doorway are called the *jambs,* the top the *lintel,* and the bottom the *sill.* The frame upon which doors are hung and which is placed in the doorway as a framing for the opening is sometimes called the *door box.*

Doors may be classified in a number of different ways. When classified by construction, they may be *frame* or *batten* doors; by materials, they may be *wood* or *metal* doors; and when classified according to method of operation, the divisions become *swinging, sliding, folding,* and *automatic* or *self-closing.* A *frame* door, which is the kind most commonly used, is made up of two sides or upright pieces, called stiles, a number of cross-pieces called rails, and thinner pieces which fill the spaces between the stiles and the rails, called panels, Fig. 45. A frame door sometimes has the panels of plain or wired glass instead of wood. A *batten* door, Fig. 46, is made up of a number of boards laid flat and held together either by tongue and groove, by tenons, or by means of binding pieces or strips laid across them, the latter giving them lateral stiffness.

Iron doors are still found in the older types of buildings, but the increasing use of steel in its place makes it proper to understand the difference between an iron door and a steel door. Iron doors are usually made of a somewhat heavy iron plate, usually a fraction of an inch thick, and may be reinforced by straps or battens. This may be considered a *plain* iron door of the iron plate pattern. Another type, which is made of a lighter sheet of metal, is called a *crimped* iron door, because of the method of treatment of the sheet. Corrugated iron is occasionally used for doors and a few examples of the boxed pattern may also be found.

The *steel* door is sometimes constructed entirely of sheet steel, usually in hollow form, reinforced by ribs inside the two coverings, but is more generally built with a wood frame or core and a covering of sheet steel. The name Kalamein (or Kalamine) has come to be applied incorrectly to the latter type of door because the first sheet metal used in the construction of doors and other articles was obtained from Kalamein iron ore. Today, although the use of this particular ore has practically been discontinued, the word Kalamein is so well established that it will always be used to denote that particular type of door or other wood articles covered with sheet steel.

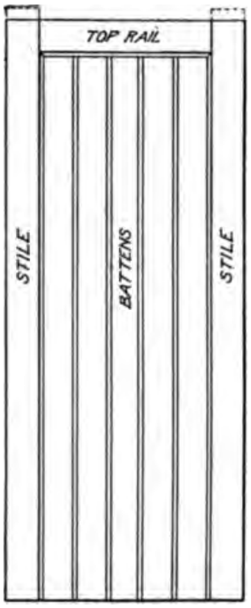

Fig. 46. Batten Door

The best type of Kalamein or sheet-steel doors are those whose metal sheets are pressed onto the wood core in such a manner as to bind very closely the metal and the wood, making nailing or other attachment practically unnecessary. This type should be distinguished from those which are more loosely covered with steel sheets held together by the liberal use of nails.

The ordinary metal-clad door is one whose covering is made of any kind of metal and attached in any manner whatsoever. Of course such a door has some claims to being called a metal-clad door, and its fire protection value is greater than a wood door without any metal covering. But the door with sheet zinc, tin, iron, or steel loosely attached has decidedly not the same fire-resistant value as a wood door with the metal attached in a close-fitting and permanent manner. This applies not only to the Kalamein, but also to the *tin-clad* door constructed according to recognized specifications of the various Fire Insurance organizations, the description of which is postponed for the present.

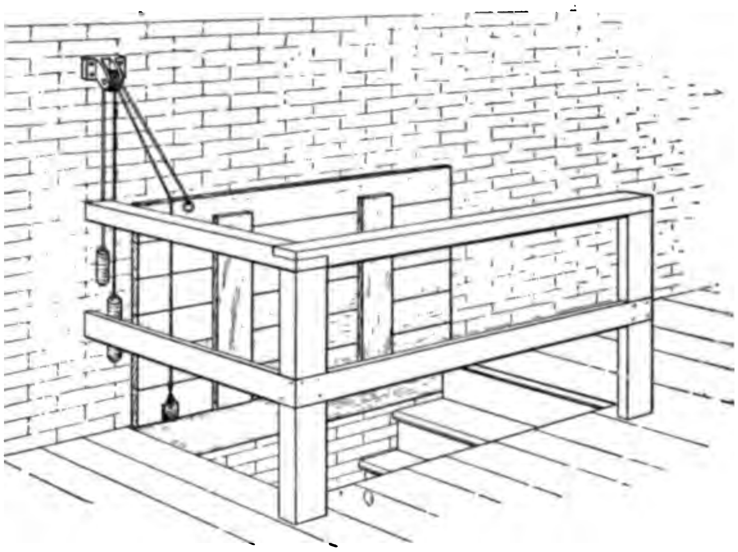

Fig. 47. Self-Closing Trap Door with Fusible Link

A type of metal or iron door that should be noted is the *rolling-shutter* door, which is in rather common use outside the doors and windows of first floors or street floors of many business buildings.

Swinging doors are hung on hinges attached to the jambs or sides of the doorway.

Sliding doors run on tracks or are attached to wheels running on tracks. These may be horizontal or vertical, the vertical type being sometimes known as *guillotine* doors. This door is also called a *channel* door, because the door proper runs in a track made of channel irons.

Folding doors are made in several parts, either hinged together or operating on different tracks so that each leaf may be extended as needed to make a continuous door.

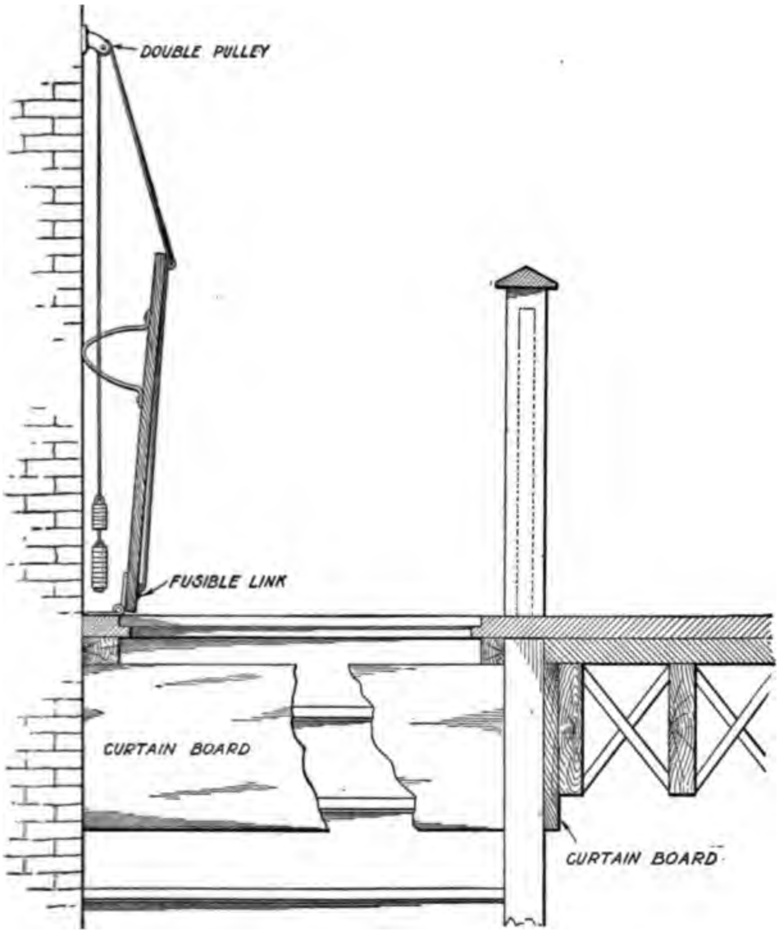

Fig. 48. Section of Construction Shown in Fig. 47 Showing Details

Automatic or self-closing doors, from a Fire Insurance standpoint, do not include doors that are closed by the operation of door checks or springs, but only those which are arranged to close of themselves in case of fire, usually by means of a fusible link, which is melted by the fire, thereby starting the closing mechanism. This closing mechanism is ordinarily a spring, in the shape of a spiral or a straight rod, which is attached to the door and to the door frame. Another method of making a door self-closing is by using a weight and cord, which is run over a pulley, Fig. 47 and Fig. 48. There are also many patent devices in use. The ordinary swinging door may be made self-closing in case of fire, provided it has a closing spring attached to it, by the use of a fusible link and the ordinary hook and eye. The fusible link is attached to the hook, which holds the door open, so that when the fire melts the fusible link, the hook pulls apart from its fastening and the door is then closed by the operation of the spring.

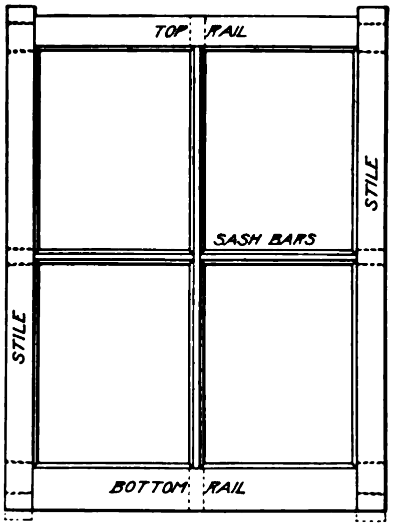

Fig. 49. Standard Wood Window Frame

Duplicate doors are sometimes used on each side of an opening, thus providing two separate and distinct cut-offs to the opening. From a fire protection standpoint, the provision of duplicate doors has been found to be of enormous advantage, because there are many instances on record where duplicate doors under fire test have withstood the most intense fires. As a rule one door is practically destroyed, but not before it has served its purpose of a buffer door and thereby saved the second door from receiving the same heavy attack.

Windows. The construction details of a window include the window frame and the setting of the window frame and box. The *window box,* like the door box, consists of jambs or sides, a lintel at the top, and a sill at the bottom. The *window frame* may be subdivided, like the door, into stiles and rails, although the term ***sash*** is used to describe the framework. Window frames are subject to practically the same classification in point of construction as doors, Fig. 49, *i. e.*, wood or metal frame and sash with plain or wired glass. The use of sheet steel or Kalamein covering is also general for windows.

The manufacture of fire-resistant windows has developed to a very considerable extent, so that there are now on the market and in general use, a number of different types of fire-resistant windows.

Transoms. This is the term applied to what are virtually small windows set over a door and used for light and ventilating purposes. They are usually hinged at the bottom or at the center so that they may readily be opened as needed.

CHIMNEYS, FLUES, AND FIREPLACES

Fire Insurance is interested in chimneys, flues, and fireplaces, because they are used in heating a building and because their construction is a factor in many fires.

Definitions. The term chimney is sometimes used to cover the flue as well as the fireplace where the fuel is burned. The detailed parts of the chimney may be described as follows:

The *walls* of a chimney include the construction work that encloses the flue or smoke opening. When the chimney consists of a number of flues or openings, the partitions or interior walls of the chimney are called *withes*.

The *chimney flue* is the opening through which smoke, gas, and other products of combustion escape, as well as the means of providing the proper draft to make the fire burn well.

The *throat* of the chimney is the opening from the fireplace to the flue.

The *fire box* is the enclosed space where the fire burns.

The *fire back* is the rear part of the fire box.

The *fireplace* is the lower part or floor of the fire box.

The *fire board* is the covering put in place during the summer, when a fire is not used. It is sometimes called the *summer piece*.

The *chimney breast* is the construction built beyond the face of the walls or flue lining.

The *hearth* is the floor space in front of the fireplace and the chimney breast.

Construction. Chimneys are usually constructed of brickwork or stonework and sometimes the flues are lined with metal or tile. In case the flues are not lined, it is important that the masonry joints on the inside of the chimney be struck smooth. Parging mortar should not be used in building chimneys and the flues should be cleaned after the building is completed. Chimneys should be built from the ground up and not on the floor or on wood beams. Where chimneys are not built up from the ground, they may sometimes be constructed by corbelling or building out the brickwork from the face of the wall, or the base of the chimney may be supported on iron brackets.

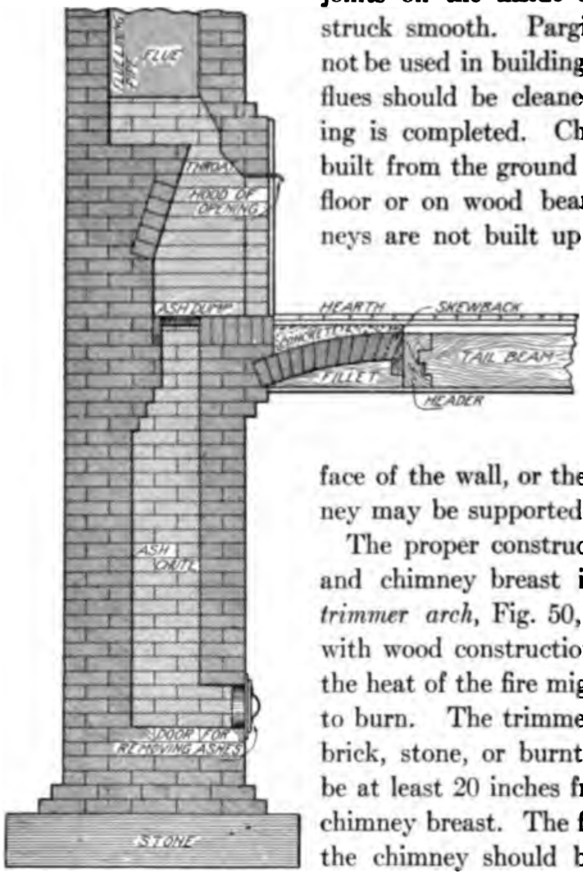

Fig. 50. Chimney Masonry Showing Trimmer Arch

The proper construction of a fireplace and chimney breast is by the use of a *trimmer arch*, Fig. 50, which does away with wood construction in places where the heat of the fire might cause the wood to burn. The trimmer arch is made of brick, stone, or burnt clay, and should be at least 20 inches from the face of the chimney breast. The floor beams around the chimney should be framed clear of all heat passages or heated places. *Trimmer beams*, that is, the beams set at right angles to the walls, Fig. 51, should be 8 inches from the inside of flues, when the flue walls are 8 inches thick, and 12 inches from the inside of flue walls, when they are less than 8 inches thick. The trimmer beams should also be at least 4 inches from the outside of the chimney breast. The *header beams*, that is, the beams that run parallel to the brick wall, should be at least 2 inches from the outside of the brickwork, which is part of the chimney.

The flues for ordinary dwelling buildings should have 4 inches of brickwork and in addition be lined with cast iron, well burnt clay, or terra cotta pipe, Fig. 52. The flues for boilers, furnaces, bakers' ovens, large cooking ranges, and large laundry stoves, should have brick walls 8 inches thick. The flues for smelting furnaces should have double walls.

SKYLIGHTS

Fire Insurance is interested in skylights as a feature of building construction because they may play an important part in the spread of fire, particularly in case fire brands of sufficient weight are carried through the air and fall through the skylight glass, thereby entering a building and starting a fire within. Again, if flames break through the roof of an adjoining building, the glass in the skylight is liable to crack or melt, thereby giving free entrance to the flames.

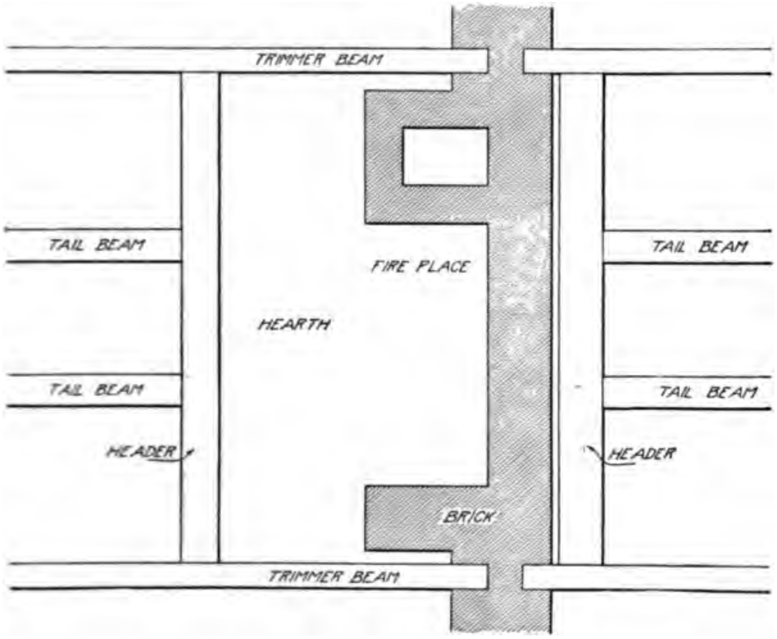

Fig. 51. Horizontal Section Showing Use of Trimmer Beams

On the other hand, in the case of interior fires, a skylight acts as a ventilator to permit the exit of smoke and flames, and thereby assists in carrying off flames and smoke. It is, therefore, desirable to have skylights designed and constructed to resist exterior fires without interfering with their acting as proper ventilators for fires

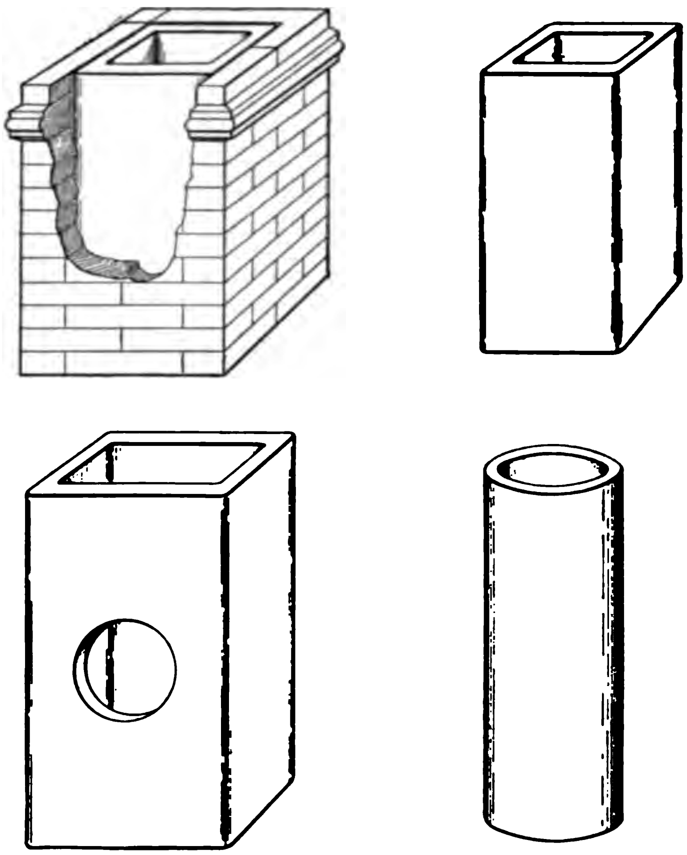

Fig. 52. Forms of Tile Chimney Lining

within a building. The most common method of providing outside protection is to have skylights made with metal frames with wired glass. To answer the purposes of fire ventilation, plain glass is used and protected on the outside by a strong wire screen.

Construction. A skylight consists of a frame into which the glass is set and fastened by the use of putty or some mechanical arrangement. Skylights are classed as *wooden* skylights or *metal* skylights according as the materials used in the frame and support are wood or metal. Only the metal skylight will be considered.

Metal. Metal skylights are made of galvanized iron, brass, or copper with joints riveted and then soldered. Solid iron plates are

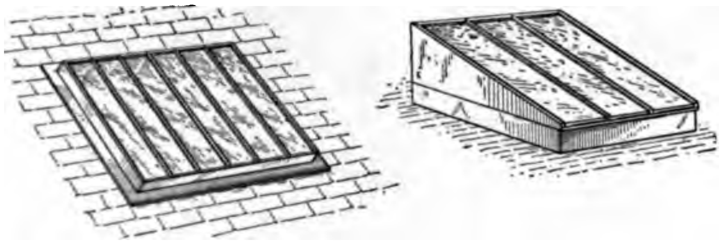

Fig. 53. Types of Flat Skylights

also used—what is called the *bull's eye pattern*—in which the glass is very thick and set in cement.

An ordinary *flat* skylight, types of which are shown in Fig. 53, is either set into a slope of a pitched roof or if placed on a flat roof is given sufficient pitch to make it drain.

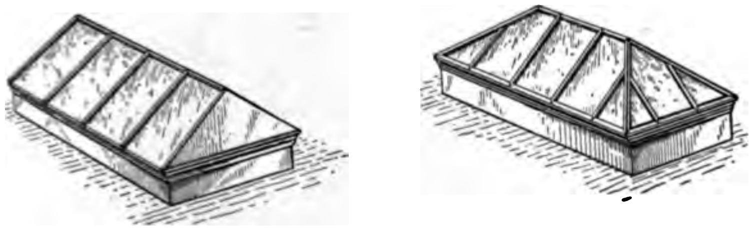

Fig. 54. Types of Double-Pitch and Hipped Skylights

Raised skylights, Fig. 54, include *double-pitch* skylights and *hipped* skylights.

Turret or *Monitor* skylights are practically skylights placed on a box or base, the sides of which will contain glass or fixed openings for ventilation arranged with louvres, Fig. 55. The turret or monitor skylight is sometimes built along the length of a building as in the case of piers, sheds, and factory buildings, and is then called a *Texas* or *long monitor* skylight.

The *studio* skylight is more like a window than a skylight, because it is placed in a vertical position like a window, while skylights are usually placed in a horizontal position on the roof of a building.

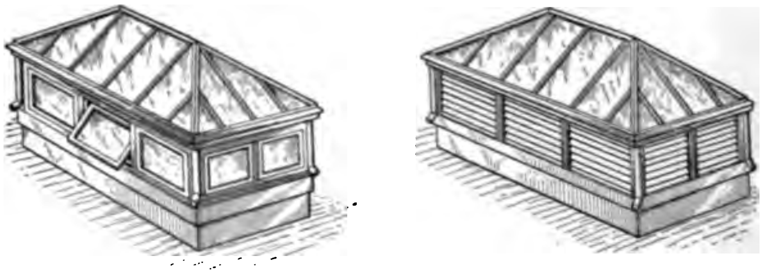

Fig. 55. Turret or Monitor Skylights

Skylights over rear-extensions of buildings, Fig. 56, are, of course, very common.

The *saw-tooth* skylight is the idea of the studio skylight adapted to the roof of car barns, repair shops, factories, etc. By this device the roof area is made to a large extent of glass, and the maximum light obtained.

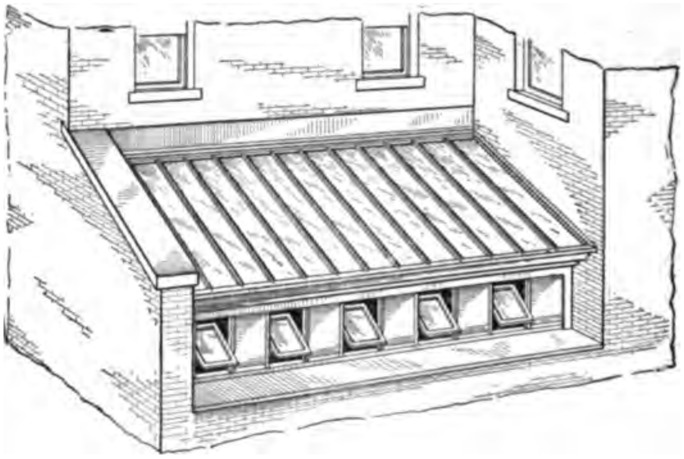

Fig. 56. Rear-Extension Skylights

Theater skylights are erected over the stage portion of theaters, and are held in position and operated by tackle pulleys and cords, so arranged, that in the case of fire, the skylights will automatically open, and permit the smoke, heat, and flames to escape through the openings, thereby causing a draft in the direction of the stage roof and away from the auditorium of the theater.

Location. Skylights are also differentiated with respect to their location, *i. e.*, whether they are in the roof of the main building, in the roof of the extensions, or over floor openings or shafts. The principal reason for making this distinction as to location is because skylights in the roof proper are usually constructed and designed to offer the strongest possible resistance to an outside fire, while the skylights over the floor openings are designed to conform to both inside fires and outside fires.

Screens. Screens which are provided in connection with skylights may be inside or outside the glass. The former are provided as protection to the occupants of the building against pieces of broken glass falling upon them and has no relation to Fire Insurance.

The inspector is interested, however, in the outside screen, which is used when the skylight glass is plain thin glass. This screen must be of sufficient strength to resist fairly large-sized timbers, one specification often used being No. 12 gauge wire with 1-inch mesh. The screen should be raised above the glass 6 inches or more, and should be extended 6 inches beyond the glass surface at the sides. It should be strongly attached, usually by riveting the frame of the screen to iron brackets, which in turn are riveted to the frame or base of the skylight. The use of solder for attaching the screen is not advisable because the solder would be melted by large fire brands, and the efficacy of the screen destroyed.

GLAZING

Window glass is of two kinds: *plate* glass, and *sheet* or *cylinder* glass, the latter being the more common. Sheet glass is made by blowing a cylinder of glass, which for the larger sizes has to be about 15 inches in diameter, and 7 or 8 feet long. When cold, the ends are cut off, the cylinder is cut open lengthwise and heated in an oven, until it is hot enough to open and spread out into a sheet. Such a sheet will afford a piece of glass 40×60 inches, which is the largest regular size.

Plate glass is not blown but is cast in plates on iron tables 15×25 feet; on these tables it is compacted and made of uniform thickness by a roller, which leaves it ½ to ⅝ of an inch thick. These sheets are then annealed and ground with sand and emery to a thickness of 3/16 to ¼ inch, and finally polished. A thinner sort called *crystal plate*, about like double thick sheet glass, is used for car windows and the like. Selected sheets of plate glass are reserved for silvering and are called *mirror plate.*

Ordinary putty is a mixture of whiting (pulverized chalk) and raw linseed oil, some makers adding about 5 per cent cotton oil to increase the keeping quality. It is mixed by machinery, or by hand, to a stiff mass like dough.

Before putting the glass in place, the workman spreads putty along the ledge on which it is to rest; this is called *bedding the glass.* The glass is then pressed firmly into place and fastened there with little triangular bits of sheet zinc called *glaziers' points*, which are laid flat on the glass, from 9 to 12 inches apart, and driven into the wood of the sash with a 2-inch chisel, held with its flat side on the glass, and the edge away from the glass; *i. e.*, with the back of the chisel down, so as not to scratch the glass. These points, which are not steel, but zinc, so they may readily be bent, are found usually in two sizes, No. 1 for double-thick glass, No. 2 for the lighter glass. For fireproof wooden sash which are covered with thin sheet metal, triangular steel lugs are made, ⅞ inch long, 3/16 inch wide at the wide end, and 1/16 inch thick; these are also used for plate glass. It is important to use enough points.

The glass used in skylights varies considerably. Ordinary glass similar to that used in window panes is known as *plain thin glass*, or *¼-inch glass; heavy glass* is thicker, usually running ⅜ to ½ inch. *Deck glass* is still heavier, while *prismatic* glass is of special form for increasing the amount of light entering a floor or building.

PAINTING

Fire Insurance is interested in the painting of a building insofar as the painting increases the danger of fire starting, or spreading after it has started.

Materials. Paint is composed of two parts: a liquid, which in most house-paints is mainly oil, and a powdered solid, which gives

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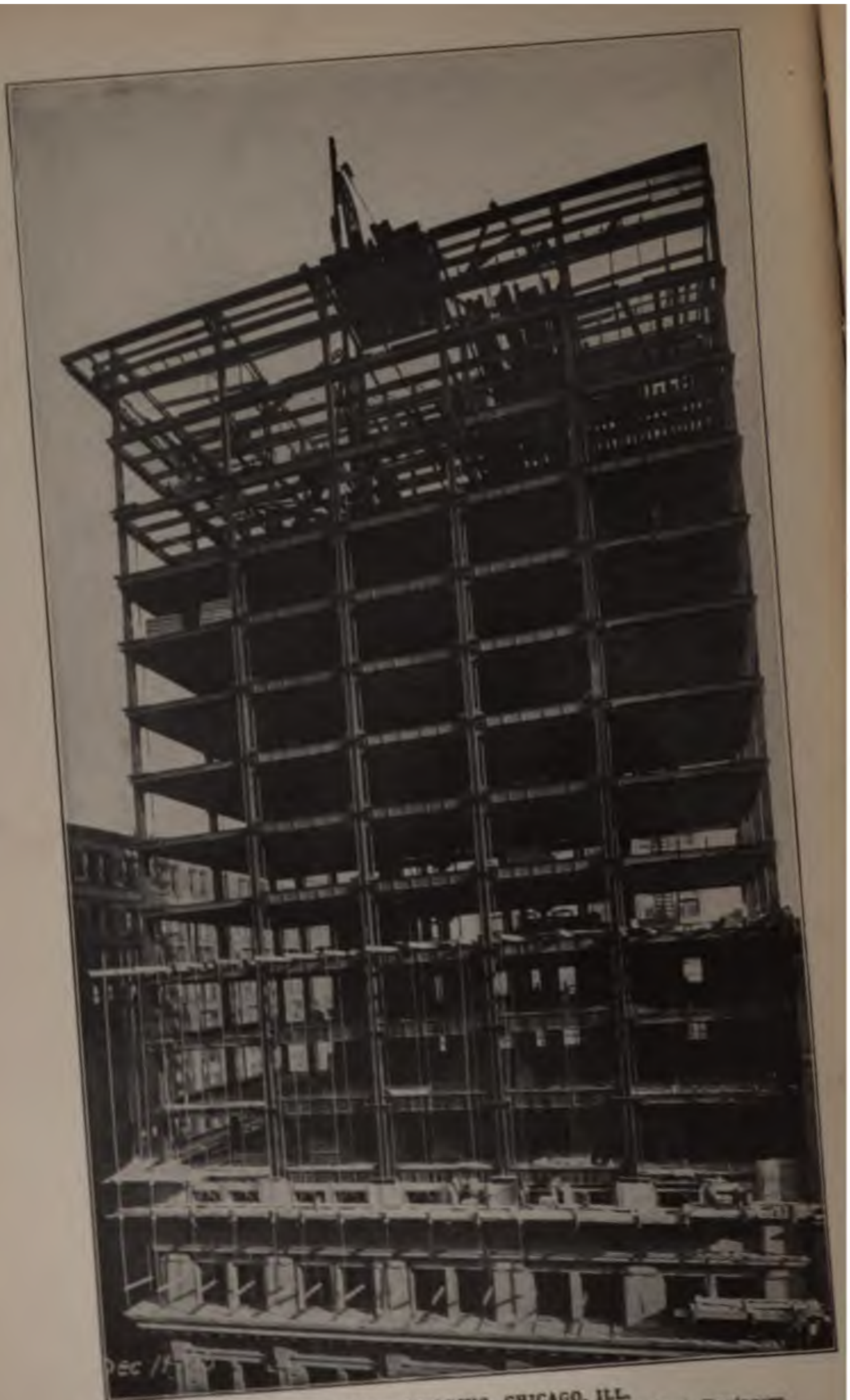
TILDEN FOUNDATIONS.



BORLAND BUILDING, CHICAGO, ILL.
Shepley, Rutan & Coolidge, Architects. E. C. & R. M. Shankland, Engineers.
Stone and brick exterior. View taken six months after building was begun.
Building completed in fall of 1906.

color and body to the mixture. The liquid part is especially termed the *vehicle;* the solid, the *pigment.* The oil is linseed oil, made from flax-seed; the *raw* or natural oil, if exposed to the air in a thin film, will dry hard enough to touch, in about a week, while *boiled* oil is the same with a small proportion of "drier" added so that it will dry in from twelve to twenty-four hours.

Paint drier, also known as *japan*, is a compound of lead or manganese, or both, which is soluble in oil; it absorbs oxygen from the air, and passes it over to the oil, for oil dries, not at all by evaporation, but by uniting chemically with the oxygen of the air, so as to make a new material, not a liquid, but a tough leathery solid, which weighs a fifth to a quarter more than the oil from which it is made.

Turpentine is sometimes an ingredient of paint, and in this connection, the essential oil of turpentine is always meant, a colorless liquid which, lighter than water, is highly inflammable and volatile. Turpentine mixes perfectly with oil, and increases the fluidity of paint. Its substitute is usually benzine—a petroleum product between light naphtha and kerosene—often mixed with resin spirits, or with wood distillates to conceal the odor.

Pigments. The most important pigment is *white lead.* Dutch process white lead is standard, being made from metallic lead corroded by the aid of acetic acid. It is a basic carbonate of lead, a very white, impalpably fine powder, heavy, as all lead compounds are, and having a natural affinity for oil. It is sold as dry white lead, although usually containing 10 per cent of linseed oil, and is a thick, heavy paste, to which oil may be added by stirring it in with a stick or paddle.

Sublimed white lead is a very different thing. It is made directly from ores containing lead and zinc by roasting them in a furnace; the lead is converted into a basic lead sulphate, and the zinc into oxide, and these are carried off in a current of air, and after cooling are collected as a white powder containing about 5 per cent of zinc oxide. Zinc-lead is a similar compound containing a very much larger proportion of oxide of zinc.

Next to white lead in importance is *white zinc*, or zinc oxide, usually made by burning zinc ore in a current of hot air, though French zinc is made by burning the metallic zinc.

There are two principal blue pigments, *ultramarine* and *Prussian blue;* the most important yellow is chromate of lead, or *chrome yellow; ochre* is a dried and powdered yellow clay containing iron and is of a dull yellow color; green is a mixture of chrome yellow and Prussian blue, called *chrome green.* For bright red a pigment is usually made by precipitating a coal-tar color on barium or lead sulphate or some other neutral base. *English vermilion* is too costly to be used much in house painting; the dull reds are oxides of iron, such as Venetian red, Tuscan red, Indian red, and the like, while the browns are also iron oxides. The blacks are either bone-black or lampblack, though graphite is used as a preservative paint on metal.

"Fireproof paint," which is sometimes used on shingle roofs, is made by adding to a gallon of any good paint about a pound of powdered boracic acid. This is not really fireproof, but retards the spread of fire, the heat fusing the boracic acid to a sort of glass which keeps out the air. It is of no value until it gets thoroughly dry and in the course of a year or two the acid is washed out by the rain; however, for a time it has considerable effect.

Varnishing. There are two principal kinds of varnish, *spirit* and *oleo-resinous.* The most important *spirit varnish* is a solution of shellac in alcohol; the American standard is made by dissolving five pounds of shellac in a gallon of alcohol, but this is too heavy for common use, three and a half pounds being more generally suitable. Shellac is naturally dull orange-yellow in color, and is called *orange* shellac in distinction from *white* shellac, which is the orange bleached with chlorine. It is of better quality before bleaching, but, of course, darker in color. In spirit varnishes, the liquid, or vehicle, is volatile and serves as a means of spreading the resin in a thin, uniform film. *Damar* is another spirit varnish, and is a solution of damar resin in turpentine.

Oleo-resinous varnishes are made by dissolving certain resins in linseed oil, with the aid of heat, and as one effect of the resin is to thicken the oil, they are thinned with turpentine or a substitute. The larger the proportion of resin, the quicker they are to dry, also the harder and more lustrous, but also the less elastic and durable. The best of these are more durable than the spirit varnishes.

The resins used in varnish-making are of vegetable origin, and come from the warmer parts of the earth, mostly from Africa, the

Philippine Islands, and from Brazil; one important and valuable resin comes from New Zealand, which is outside the tropics. The resin forms in lumps on the trees, just as spruce-gum forms on spruce trees in this country, but in larger pieces. This fresh resin, however, is as a rule too soft to make good varnish, the usable product being, for the most part, dug up from the earth; the trees which produce it have long ago fallen and decayed, and the longer it has been in the earth the harder and more valuable the resin.

Resins are of many different kinds, and are believed to have been produced by various hardwood trees. The varnish-maker puts 100 pounds of resin in a kettle over a hot fire, and when it is melted, which is at about the temperature of melted lead, he puts in hot linseed oil. If he puts in oil equal in weight to the melted resin—which has lost between a fifth and a fourth of its weight in melting—he will make a hard, lustrous varnish, suitable for tables and other furniture; if he puts in twice this amount, he will have a varnish suitable for general interior house-varnishing, elastic and durable, but not quite hard enough for furniture; if he puts in three times as much oil as resin, he will make a very elastic, durable varnish, which will get hard out of doors, but indoors will harden too slowly for practical use. After the oil is put with the resin, the compound is cooked several hours until it has thoroughly united, then turpentine is added in sufficient amount to make it thin enough to use, for it is evident that without it the resin will have thickened the oil so that it will not brush out.

The painting or coating of wood and other combustible building materials for the purpose of preserving the materials or for decorative purposes may, at the same time, increase or decrease the fire danger. Naturally wood surfaces that are painted or coated with varnish, shellac, or oil serve to spread fire rapidly, and for this reason paints which to some extent may be considered fire-retardant, are to be preferred. A kind known as "cold-water paint," will be referred to later. *Whitewash* is one of the best fire-retardant paints known, and because of its value in this respect, the formula recommended by the Lighthouse Board of the United States Treasury Department is given as follows:

"Slake one-half bushel of unslaked lime with boiling water, keeping it covered during the process; strain it and add a peck of salt dissolved in warm

water; three pounds of ground rice, put in boiling water and boil to a thin paste; one-half pound powdered Spanish whiting and a pound of clear glue dissolved in hot water; mix these well together and let the mixture stand for several days. Keep the wash thus prepared in a kettle or portable furnace and when used put it on as hot as possible with paint or whitewash brushes."

Where possible, the coatings should be applied by a hand brush rather than by a spraying machine, thus effecting a better surface; special care should be exercised not to coat sprinkler heads where installed.

During the process of painting a building a particular danger exists because of the quantity of oils of more or less inflammable and volatile nature which are used with the paints for thinning or drying purposes. In respect to the drying of paints, it is needless to say that the use of benzine is liable to result in fire. Aside from the paints themselves, Fire Insurance must consider that the careless habits of the painters, the paints, pots, and brushes, the men's work clothing, the ladders, cloths, paper, and a general collection of good fire materials greatly increase the fire hazard of a building under construction.

Redecorating. In reconstruction work, paint or varnish is sometimes burned off with a *painter's torch*, burning alcohol, naphtha, or kerosene. The strong blast of flame, when directed against the paint, does not really burn it, but softens it so that it may immediately be scraped off with a steel scraper.

Varnish remover is a liquid which will dissolve dried varnish and paint, thus softening the film so that it may be scraped off or rubbed off with a very stiff scrubbing brush. Varnish removers consist mainly of acetone, benzole, and similar liquids, and the best of them which are patented, contain, in addition, some waxy substance to prevent the film from drying too rapidly. They are inflammable and must be used with care. After removing the loosened film of paint or varnish, the surface is washed off with benzine.

Kalsomining. Kalsomine (or calcimine) is much like whitewash, being a water paint having lime as a base; but whereas whitewash is a mixture of fresh caustic water-slaked lime, and has enough adhesive quality to make it stick fairly well by itself, kalsomine is made of the carbonate of lime—chalk ground to a fine powder and known as whiting, Paris white, or Spanish white—mixed not with pure water but with size, a thin solution of glue, which forms the binder. To make it, fifteen or twenty pounds of whiting are mixed with enough water to make a thick paste; half a pound of good white glue, which has previously been dissolved in water, is added to this, together with enough hot water to make about one-fifth as many gallons as there are pounds of whiting—that is, five pounds of whiting should make a gallon of kalsomine. When cool, it will be a jelly, and is then ready for application.

Cold-Water Paints. These are related both to whitewash and to kalsomine; to the former because they contain quicklime, and to the latter because they contain a glue-like cementing material, *casein*, which is obtained from milk, and is on the market as a white powder, soluble in a solution of any alkali in water. In the early days of cold-water paints, *borax* was used as the alkali base, but this was a failure, because the compound formed by it and casein was not altogether insoluble when dry; the mixture of casein and lime has not this drawback. When water is added to this mixture, the casein first dissolves in the lime-water, then it combines chemically with more lime, and this lime and casein compound, when dry, is insoluble and forms a cement of considerable strength. The paint is put up in dry powder form, containing whiting and coloring matter in addition to the proper amount of casein and powdered quicklime.

MILL CONSTRUCTION

The terms *mill construction* and *slow-burning construction* have originated from the system of building mills and factories according to the ideas of the Associated Factory Mutual Fire Insurance Companies, the first referring to that type of construction using timber and plank in heavy solid masses for the interior construction of a building, and the second consisting of additional measures designed to retard the spread of fire or control and possibly extinguish it.

The principles of slow-burning construction call for the separation of every floor from every other floor by incombustible stops; for example, by automatically-closing hatchways, and by encasing stairways and belts in brick or other incombustible partitions, so that a fire shall be retarded, in passing from floor to floor, to the greatest possible extent consistent with the use of wood or other combustible construction material. They also require all suitable safeguards to be provided against fire. The very title *slow-burning* *construction* clearly indicates that the methods used do not consist wholly in laying floors or roofs on thick planks and heavy timbers, spaced wide apart, but that every effort is made to give the exposed surfaces of wood suitable protection. Wood surfaces will surely burn rapidly, especially if finished with varnish, thus promoting the swift spread of fire upon or under such wooden surfaces unless there be some provision for stopping them.

The advocates of slow-burning construction do not pretend to hold to the opinion that such construction is the equal of the so-called "fireproof" construction, in fire-resisting qualities; yet the regulation mill-construction floor, suitably constructed with 3-inch plank, grooved and splined, covered with 1-inch top boarding laid on timbers 8 or 10 feet on centers, and made continuous—that is, without any breaks for belt holes, open elevators, or open stairways—has seldom been burned through by a fire upon the floor or by fire passing through the floor above. The fires usually have not only been held in the building, but *in the room in which they originated.*

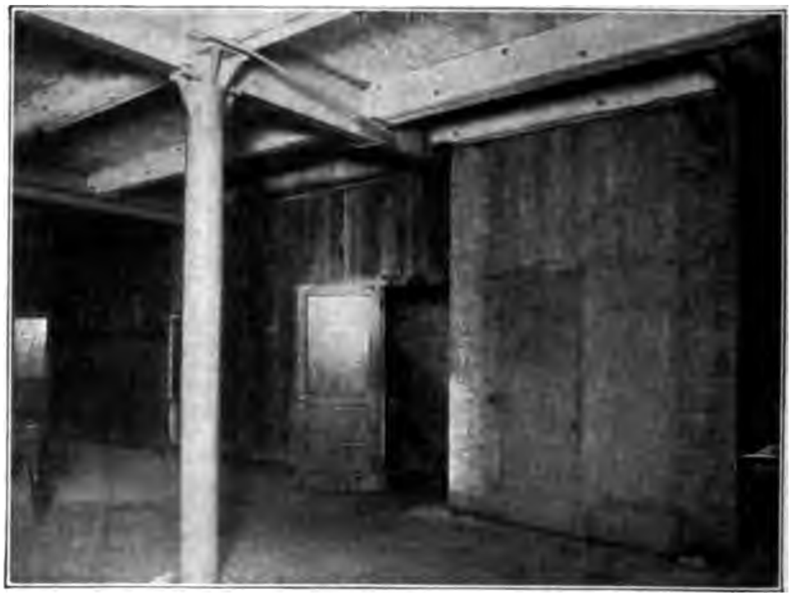


Fig. 57. Unprotected Cast-Iron Column

Another advantage of mill construction is in the use of timber posts, which offer more resistance to fire than unprotected wrought-iron, steel, or cast-iron columns in the positions shown in Fig. 57.

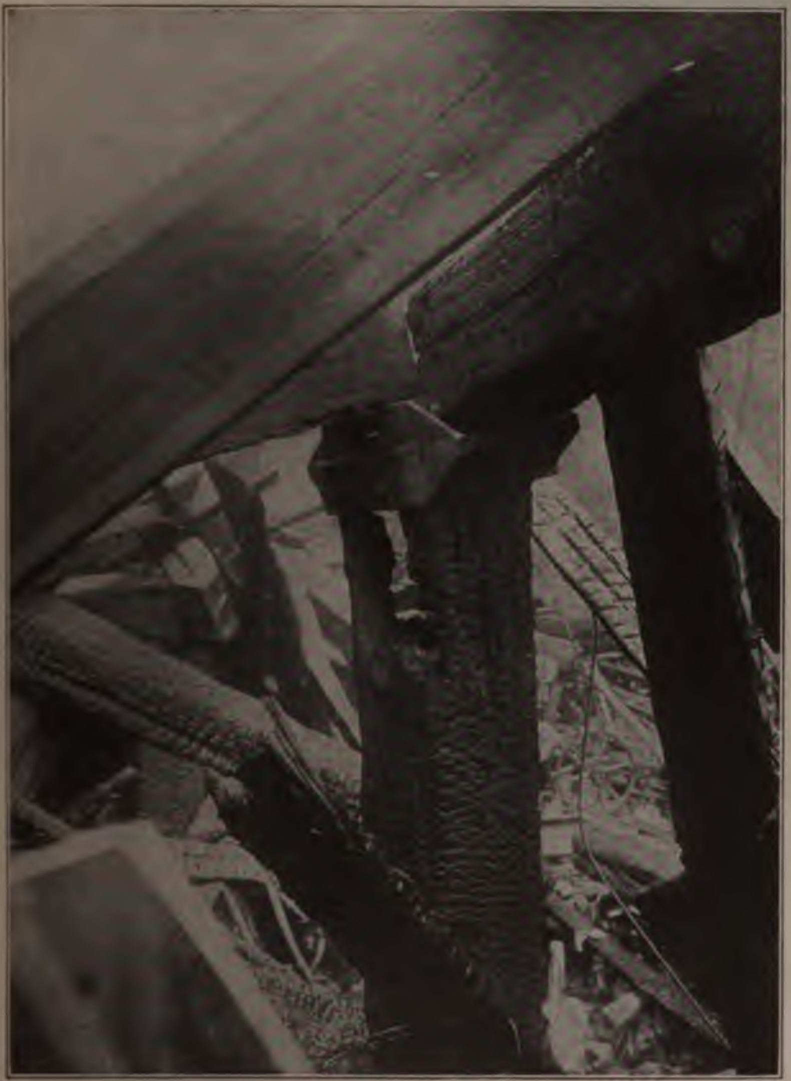


Fig. 58. Fire in Mill Constructed Building Showing Resistance of Heavy Timbers to Fire

Iron posts have been crippled or sprung by heat a great many times during the early periods of a fire, while wooden posts of proper size have never been burnt off until other parts of the building were already destroyed, Fig. 58. They have in one instance resisted fire for hours, while granite posts close by them were destroyed by cracking and scaling—the granite measuring 12 × 12 inches.

Mill Construction vs. Ordinary Construction. Mill construction, as compared with ordinary construction, is against the whole interior of a building becoming a series of wooden cells filled with concealed spaces, either connected directly with each other or by cracks through which fire may freely pass where it cannot be reached by water.

Mill construction, as compared with ordinary construction, is against the open timber construction of floors and roof, which resembles mill construction but in which the timbers and planks are thin, light, and of insufficient size, Fig. 57.

Mill construction, as compared with ordinary construction, is against connecting floor with floor by combustible wooden stairways, enclosed in wood less than 2 inches thick, Fig. 57; it is also against leaving floors without fire stops or fire guards.

Mill construction, as compared with ordinary construction, is against putting in numerous divisions or partitions of light wood; it is against sheathing brick walls with wood, especially when the wood is set off from the wall by furring, even if there are stops behind the furring.

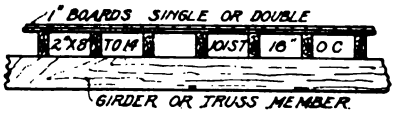


Fig. 59. Section of Floor of So-Called Mill Construction

Mill construction, as compared with ordinary construction, is against using any more wood in finishing the building after the floors and roof are laid than is absolutely necessary, because there are now many safe methods available at low cost for constructing and finishing walls and partitions of slow-burning or incombustible materials.

Mill construction is opposed to a method of construction which, although it has received the same name, allows the use of longitudinal girders resting upon posts while on the top of the girders are placed beams at 4 feet or less on centers, Fig. 59. This type of construction is not considered genuine mill construction, on the grounds that it increases the exposed surface of wood, while at the same time the disposal of the timbers is such as to obstruct the action of sprinklers and prevent the sweeping of a hose stream from one side of a room to the other. In Figs. 60 and 61 are shown good types of construction. Fig. 60 illustrates the method of laying the plank directly on timbers or girders; while Fig. 61 shows a type in which trusses, posts, or girders are widely spaced, necessitating the use of purlins to support the planks.

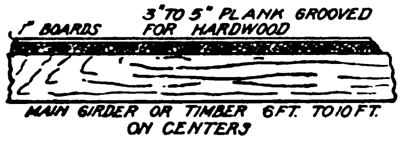

1" BOARDS
3" TO 5" PLANK GROOVED FOR HARDWOOD
MAIN GIRDER OR TIMBER 6 FT. TO 10 FT. ON CENTERS

Fig. 60. Section of Approved Floor for Mill Construction

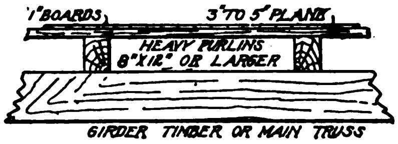


Fig. 61. Mill-Constructed Floor with Widely-Spaced Girders

There are in use at the present time practically two sets of standards for mill construction, those issued by the National Board of Fire Underwriters as adopted by the National Fire Protection Association, and those issued by the Insurance Engineering Experiment Station under direction of the Boston Manufacturers' Mutual Fire Insurance Company, an illustration of which is shown in Fig. 62. The standards are based upon the same fundamental principles, and their differences will be clear from a study of the following digest of them.

GENERAL CONSTRUCTION

National Board Specifications. *Walls.* The material of the walls is specified as good, hard burnt brick, laid in the best of lime or lime-and-cement mortar. All exposed walls are to be carried at least 36 inches above the roof and provided with a durable coping.

Bearing Walls. The dimensions for bearing walls are specified at 12 inches thick for the top story, with an increase of 4 inches for each additional story or fraction thereof; or, instead of these fixed dimensions, the wall may be of an equivalent average thickness. The ledges formed by the increased dimensions of the walls at the various stories are to be used as supports for the floor timbers which, where they enter walls, are to rest on iron plates and be self-releasing.

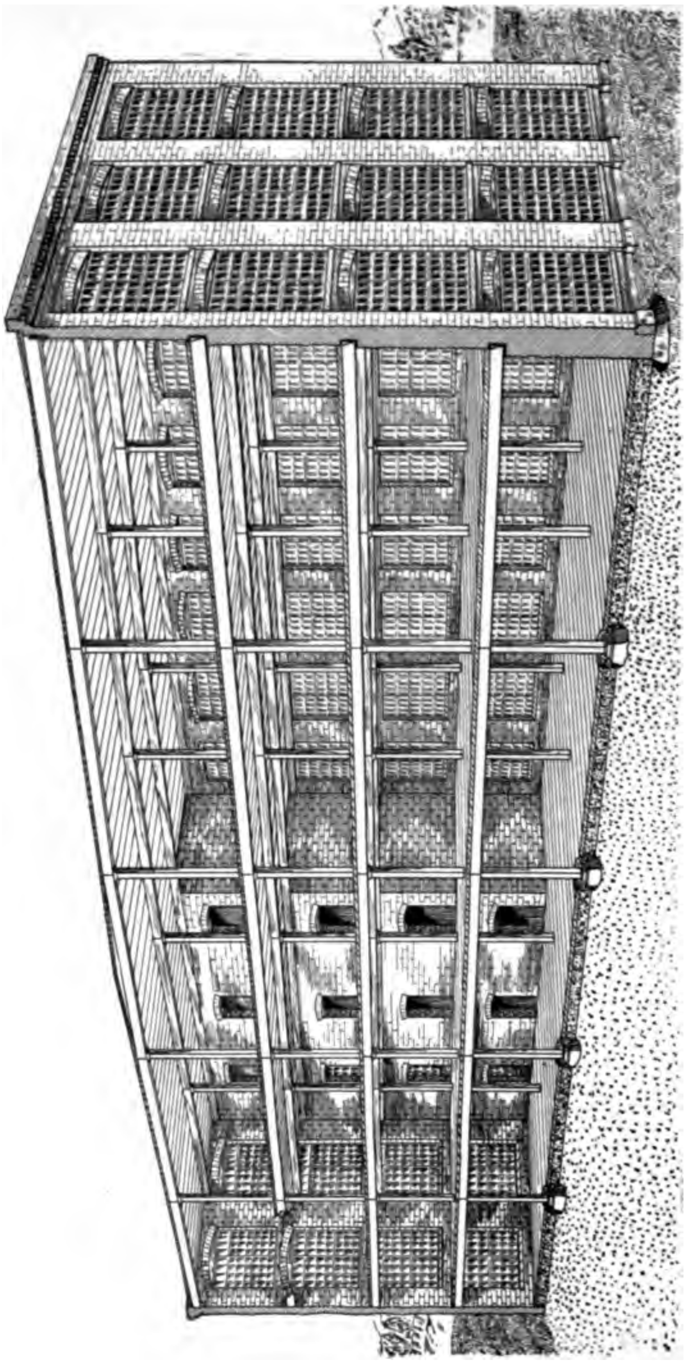


Fig. 62. Standard Mill Construction as Adopted by the Insurance Experiment Station

If the walls are of pier construction, the piers are to be well laid and flushed up full with cement and graded in size according to the weights to be carried. A minimum thickness of 20 inches is fixed for the two upper stories with an increase of 4 inches for each story below. The piers are also to be graded in width of face according to the span of the bays, the face of the pier to measure not less than one-fourth as much as the space between centers. The walls between the piers are to be not less than 12 inches thick.

Non-Bearing Walls. A minimum thickness of 12 inches is fixed for the three upper stories, 16 inches for the next three stories, and 20 inches for the stories below. In case a wall has a length over 100 feet, its thickness is required to be 4 inches more than the rules just stated, or it may be strengthened by piers or pilasters located not over 20 feet apart.

Division, Cut-off, or Party Walls. Division, cut-off, or party walls may be called upon to stop the spread of fire from one section of a building to an adjoining section, and are, therefore, likely to be subjected to severe heat as well as abnormal strain or shock by falling timbers, machinery, etc. Such walls should be exceptionally thick, strong, and well constructed. It is recommended that they be made 4 inches thicker than the rules below call for.

These walls should have a parapet 3 to 5 feet high and extending beyond the face of the wall so as to cut off the cornice. It should have a durable coping, and if the roof is metal, the roofing material should not be carried over the fire walls. In case there are monitor skylights or roof lanterns near these walls, the parapet should be built in a special manner.

If these walls are bearing walls, a minimum thickness of 16 inches is fixed for the two upper stories; otherwise the same rule of increase as for outside or independent bearing walls, should be followed.

If the walls are non-bearing walls, a minimum thickness of 16 inches is fixed for the three upper stories, 20 inches for the next three stories, and 24 inches thick for stories below. If the walls are over 60 feet in length, they are required to be 4 inches thicker, as provided for outside or independent walls over 100 feet in length.

In case wood beams enter these walls at opposite sides, there must be at least 8 inches of brickwork between the ends of beams.

All door openings in this class of wall are to be protected on each side of the wall by standard automatic fire-doors, the sliding type of door preferred.

In the case of wood buildings, the cut-off walls are to extend at least 5 feet beyond the face of the building and then be built parallel to the sides of the building at right angles for at least 5 feet in each direction.

If two sections of a building which are cut off from each other adjoin so as to form an angle, the two walls forming the angle are to be treated as exposed walls for a distance of at least 30 feet from the angle. This requires that all windows and other openings be bricked up or protected with standard cut-offs. In the case of minor sections such as boiler or engine houses, this rule is applied only to the walls of main buildings or principal sections of the building.

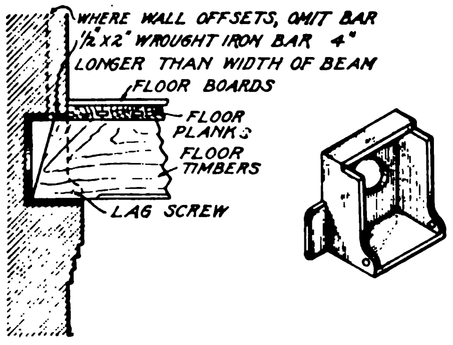

WHERE WALL OFFSETS, OMIT BAR
½"X2" WROUGHT IRON BAR 4" LONGER THAN WIDTH OF BEAM
FLOOR BOARDS
FLOOR PLANKS
FLOOR TIMBERS
LAG SCREW

Fig. 63. Self-Releasing Beam Support for Mill Construction

Mutual Specifications. *Walls.* The minimum thickness of brick walls is placed at 12 inches, with a recommendation for 6 inches at the top story, and an increase in thickness at the lower stories to support the additional load.

Walls constructed of bearing sections, called *pilasters*, and non-bearing sections called *panels*, are preferred because of advantages over plain walls.

Arches for windows and doors are recommended to be of brick, while the sills for windows and doors and the underpinnings or footings are recommended to be of granite or concrete.

Fire walls should be carried 2½ feet above the roof and provided with vitrified coping laid in Portland cement mortar.

FLOOR CONSTRUCTION

National Board Specifications. Floors are to be solid and without openings.

Flooring. The flooring or floor board is specified as not less than 3-inch splined plank covered with 1-inch dressed flooring, which should preferably be laid diagonally. Between the planks and the dressed flooring shall be laid two thicknesses of approved waterproof material, flashed at least 3 inches at the walls and around columns and openings and provided with molding or mopboard.

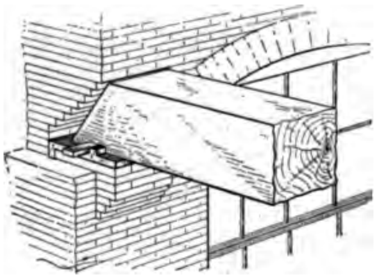


Fig. 64. Self-Releasing Type of Beam Support by Means of Inset in Wall

Floor Timbers. Floor timbers are recommended to be heavy single stick and to be suitable for the load carried, but in no case less than 8 inches in either dimension. The floor timbers are to rest on wall ledges, and where entering walls are to be self-releasing, Figs. 63 and 64. If auxiliary beams are necessary they shall rest on top of main girders, and not on strap iron stirrups.

When floor timbers rest on columns or posts, they are to be self-releasing. They shall not be bolted to walls or posts. If they enter division or party walls, they shall have 8 inches of brickwork between the ends. If floor timbers are of iron or steel, they are to be protected by not less than 2 inches of terra cotta, concrete, or their equivalent.

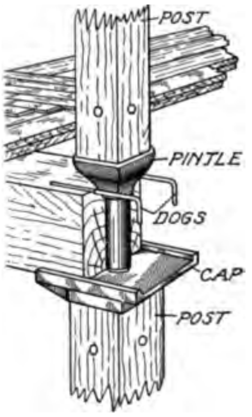


Fig. 65. Approved Cast-Iron Post Caps and Pintles for Mill Construction

Posts and Columns. Posts and columns are to be proportioned in size according to the weights to be carried. For timber posts, the smallest cross-sectional dimension is placed at not less than 8 inches; all corners of posts are to be rounded.

All posts are to be superimposed or continuously posted throughout all stories and are to be connected by properly-designed cast-iron caps with cast-iron pintle and base plate, Fig. 65. If posts or columns are of iron or steel, they are to be protected by not less than 2 inches of terra cotta, concrete, or their equivalent.

Scuppered Floors. It is recommended that, where feasible, floors be built with slight pitch, 1 inch to each 20 feet, and have proper scuppers with drain pipes, Fig. 66.

Mutual Specifications. The use of auxiliary girders or beams is not recommended. The standard construction calls for the use of girders and columns of wood. The use of cast-iron columns is accepted as satisfactory, provided the building is equipped with automatic sprinklers, but they are not considered as fire-resistant as timber. The use of wrought-iron and steel members is accepted, provided they are encased with fireproofing material.

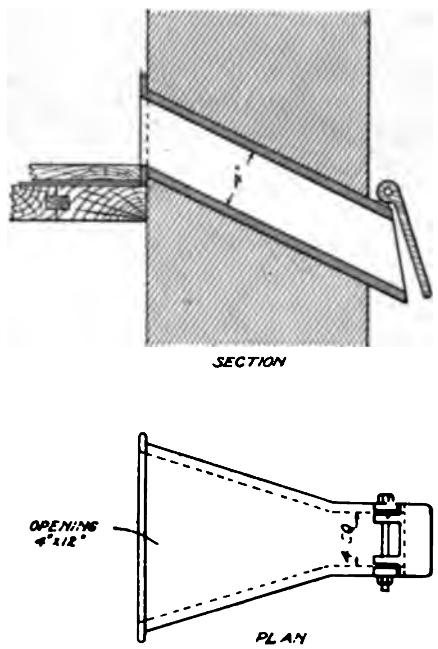


Fig. 66. Floor Scuppers with Drain Pipe

Flooring. The floor boards or flooring is specified as spruce plank 4 inches or more in thickness according to the floor loads. This is spiked directly to the floor timbers and kept at least ½ inch clear of the face of the brick walls.

The bays are fixed at 8 to 10½ feet wide and the plank is laid two bays in length, laid to break joints every 4 feet, and grooved for hardwood splines. A top flooring of birch or maple is laid at right angles to the planking, Fig. 67; in some cases a double top floor is laid, the lower one being of soft wood laid diagonally upon the planking and the upper one laid lengthwise. This double top floor allows boards in alleys or other much-used places to be easily replaced when worn, while the diagonal boards brace the floors, reduce vibration, and distribute the floor load in a better manner. Between the floor planking and the top floor boards, 2 or 3 layers of heavy tarred paper is placed, laid to break joints, and each layer mopped with hot tar or similar material to produce a water-tight as well as a dust-tight floor.

Cement floors are advised for basements or lower floors of mills, whenever wood is not absolutely necessary. If wooden floors are required, crushed stone cinders or furnace slag is spread evenly over the surface and covered with a thick layer of hot tar concrete. On this is laid tarred felt well mopped with hot tar or asphalt, on which a floor of 2-inch seasoned plank is pressed, nailed on edge without perforating the waterproofing under it. On top of this planking, the hardwood top floor boards are nailed crosswise.

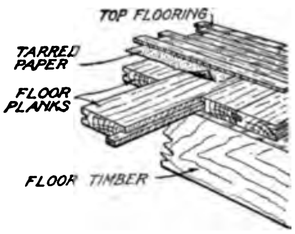


Fig. 67. Approved Mutual Type of Floor for Mill Construction

Floor Timbers. Floor timbers are recommended to be in large masses which present the least surface possible to a fire. No sticks less than 6 inches in width should be used, even for the lightest roofs, and for substantial roofs and floors, much wider ones are needed.

Timber shall be of sound Georgia pine. For sizes up to 14×16 inches single sticks are preferred, but timbers 7 or 8×16 inches are often used in pairs and bolted together without air space between. Timbers shall not be painted, varnished, or filled for three years, because of the danger of "dry-rot"; an air space shall be left in the masonry around the ends for the same reason. They shall not be covered with airproof plastering or oil paints.

Timbers shall rest on cast-iron plates or beam boxes in the walls and on cast-iron caps on the columns. Beam boxes are of value as they strengthen the walls, when floor loads are heavy and the distance between the windows is small. They facilitate the laying of the brick and the handling of the beams and there is less possibility of breaking away the brick in putting the beams in place. They also insure a proper air space around the ends of beams. When timbers rest on posts, they rest on an iron plate and are joined by ¾-inch round iron dogs on top.

Columns. Columns of Southern pine shall be bored through the center by a 1½-inch hole for the purpose of reducing checking. In case the posts are made of unseasoned wood and are painted, varnished, or filled, they shall also be bored with ½-inch holes, top and bottom, for ventilation in order to prevent fermentation ("dry-rot"). They shall be cut with their ends square with the axis. Columns shall be set on pintles, which may be cast in one piece with the cap, or separately as preferred; but the use of built-up caps or wrought iron or steel is not advised.

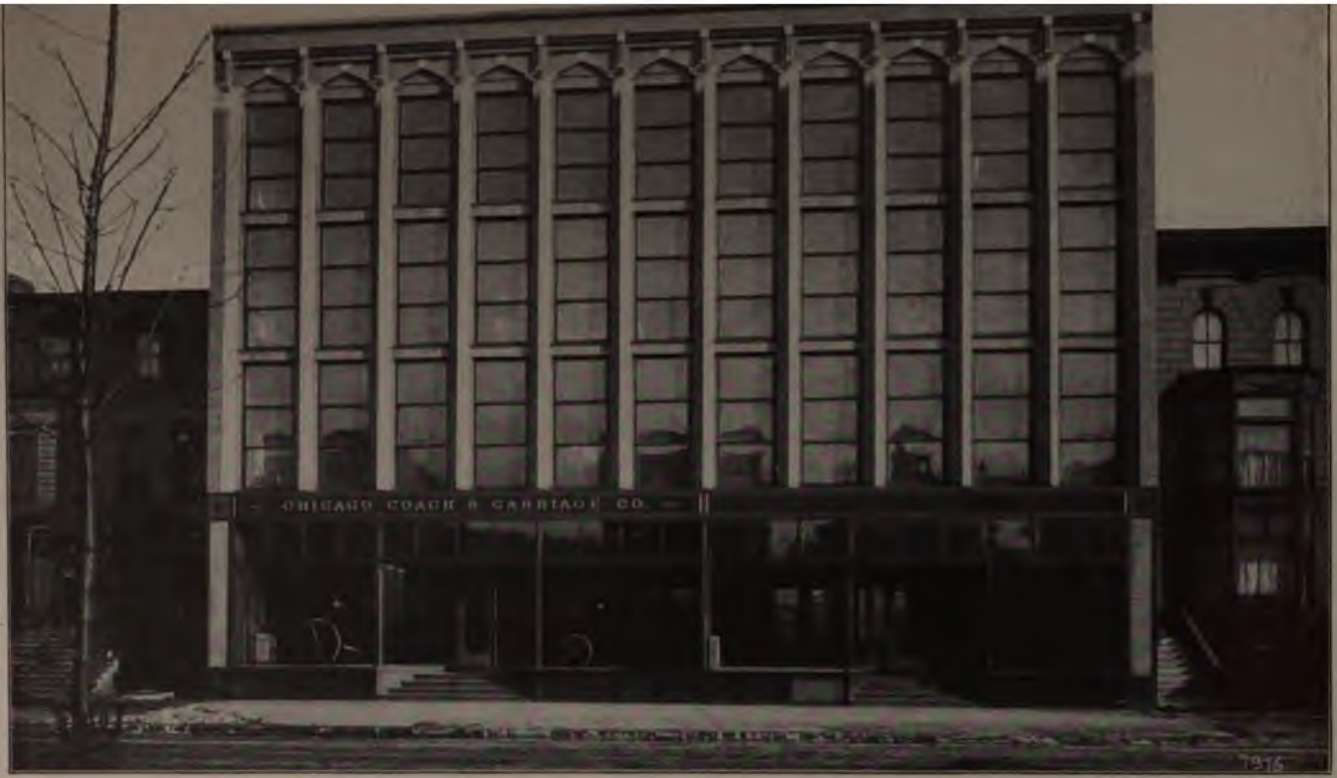
Waterproof Floors. Floors are arranged to drain into the tower sections of buildings. The floors of each story in the tower are made about 1 inch lower than the floors in the adjoining compartments. The sills are sloped to make up for this difference in level and the sill of the outside door in the tower is made lower than the tower floor. Water on floors in the tower would ordinarily flow down the stairs and elevator shafts, and the arrangement of floor levels indicated above will ordinarily prevent water flowing from an upper floor into one of the lower compartments through the tower.

Cast-iron scuppers are advised and should be set in the brickwork at frequent intervals and so designed that they will carry away rapidly a maximum quantity of water from the floors of each compartment. Water-tight floors are also desirable and become a necessity in certain warehouses containing valuable contents; in three- or four-story warehouses, however, these are not usually considered essential. In higher buildings, one or two floors are often covered with an inch of rock asphalt properly applied and turned up around posts and at walls about 4 inches.

FLOOR OPENINGS

National Board Specifications. Shafts and elevators are to be enclosed in brick shafts with standard fire-doors at all openings to a building. The walls of the shafts are to pierce all floors and extend 3 feet above the roof. Shafts are to be ventilated by ordinary thin glass windows opening outside (but not so as to expose windows in the building itself) or by a thin glass skylight protected by standard wire netting. The top of the skylight may be wired glass while the sides of the skylight may be thin glass. Shafts are to have a 3-foot drainage pit at the bottom connected with a sewer to carry off the water coming from the upper floors.

A stairway which extends through one floor only is to be of incombustible material. Communication with the floor is to be entirely cut off by a fireproof partition of terra cotta, concrete, or iron frame, with metal lathing or expanded metal plastered on both sides. A standard fire-door fitted with approved automatic devices



BUILDING FOR JOHN H. WHITTEMORE, 1223 MICHIGAN AVE., CHICAGO, ILL.

Dean & Dean, Architects, Chicago, Ill.

Mill Construction with Soft Brick Walls and Piers; Floors, Mill Construction; Partitions of Solid Plaster and Iron and Glass; Exterior of Pressed Gray Brick and White Terra-Cotta; Store Front, Cast Iron. Completed in 1905. Cost, $50,000.

[illegible]
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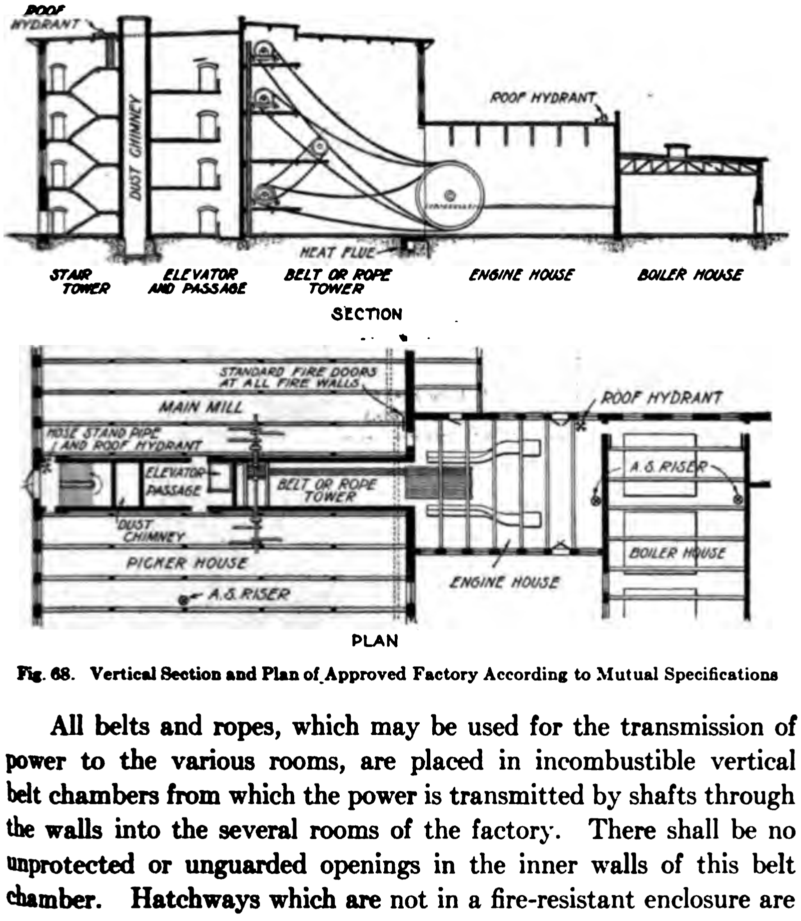
TILDEN FOUNDATIONS

must be provided at the opening in this partition. A curbing at least 3 inches high must be placed around the head of each stairway and the floor must be inclined up to the curbing.

Mutual Specifications. Elevators, stairs, and main belts are to be located in brick towers or in sections of the building cut off by incombustible walls from all the rooms of a factory. The openings in these walls are to be provided with fire-doors, preferably self-closing. These fire-doors are hung on heavy inclined solid steel rails at least 3½×⅜ inches and balanced by weights held by fusible links.



SECTION

PLAN

Fig. 68. Vertical Section and Plan of Approved Factory According to Mutual Specifications

All belts and ropes, which may be used for the transmission of power to the various rooms, are placed in incombustible vertical belt chambers from which the power is transmitted by shafts through the walls into the several rooms of the factory. There shall be no unprotected or unguarded openings in the inner walls of this belt chamber. Hatchways which are not in a fire-resistant enclosure are automatically cut off. The specific points to which attention is called in connection with Fig. 68 are as follows:

Main belts entirely separated from the manufacturing rooms by solid brick walls, to prevent fire being communicated from the power plant to the mill, or from one floor to another.

Elevator and stairs in brick tower with standard automatic fire-doors.

Closets in a separate tower rather than in the manufacturing rooms.

Boiler plant cut off from engine room by brick wall with doorway; also protected by standard automatic sliding fire-door.

PARTITIONS

National Board Specifications. Partitions of incombustible material, or of 2-inch matched plank coated with fire-retarding paint, are specified.

Mutual Specifications. Partitions of light wood are prohibited and slow-burning or incombustible materials recommended.

FINISH

National Board Specifications. Wood or other combustible finish is prohibited and a non-combustible finish without concealed space is specified.

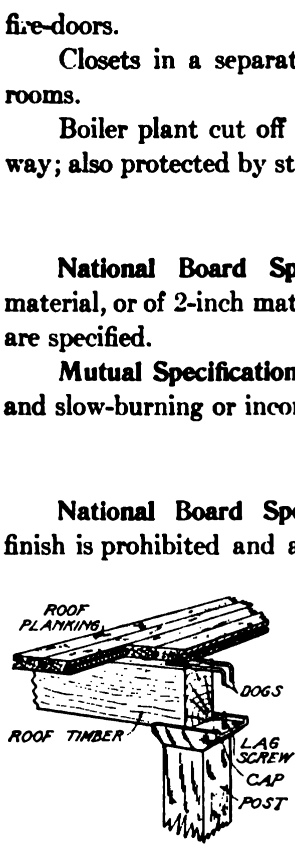


Fig. 69. Construction of Roof Timbers. Mutual Specifications

Mutual Specifications. The sheathing of brick walls with wood, especially when furred, is prohibited.

The use of varnish upon woodwork is prohibited.

Plastering, if used, should be plain lime and water plaster, which is sufficiently porous to permit seasoning. The addition of the skim-coat of lime-putty is prohibited, especially if the top floor boards are laid upon resin-sized or asphalt paper.

The painting, varnishing, or filling of timbers is prohibited.

ROOF

National Board Specifications. Roof timbers are not to be less than 6 inches either dimension, and single stick timbers are preferred.

The roof boarding is to be 3-inch splined plank and the covering is to be of metal, gravel, or approved composition.

The cornice is to be of brick or incombustible material. If of metal, it must in no way communicate with, or provide, a space communicating with the roof timbers.

Mutual Specifications. Roof timbers are not to be less than 6 inches, Fig. 69, and the boarding is 3-inch pine plank spiked directly to the roof timbers. The covering is 5-ply tar and gravel roofing.

An incombustible cornice is recommended when there is exposure from neighboring buildings. A wood cornice is constructed to be open, Fig. 70.

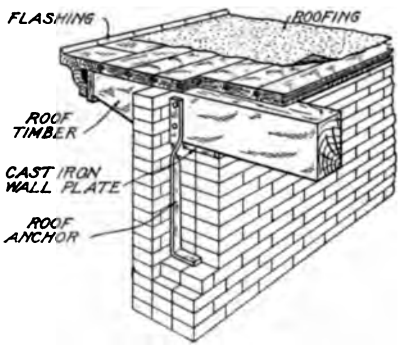


Fig. 70. Construction of Wood Cornice. Mutual Specifications

ENGINE AND BOILER HOUSE

Mutual Specifications. Boilers and engines are placed in one-story buildings cut off by a fire wall from the rest of the plant. The boiler plant is cut off from the engine room by a brick wall, and doorways in this wall are protected by standard automatic sliding fire-doors, Fig. 68.

FIRE-RESISTING MILL CONSTRUCTION

The increasing cost of heavy timber, and, in fact, of all lumber; the lessened cost of erection of the so-called *fireproof* types, entirely of reinforced concrete, or with protected steel frames and incombustible floors; and the obvious advantages of more fire-resisting construction, especially in the congested sections of cities; all of the enumerated factors and more have tended to bring these types into more general use.

In machine-shops and other plants requiring exceptionally heavy floor construction above the ground level, steel beams are of necessity resorted to, and by maintaining wide spacings of from 7 to 12½ feet, all the advantages of the standard mill construction are retained, except that of resistance to fire, provision for which, when necessary, may be made by fireproofing. To obtain unusual stiffness between the beams in this type, the floors may be made up of 2-inch joists laid on edge and spiked closely together, the thickness of the floor varying from 5 to 8 inches or more, depending upon the load and span. This floor being practically a single unit, provision must be made for contraction longitudinally by making a continuous joint in the under flooring at intervals, making arrangements, of course, for tying the building together.

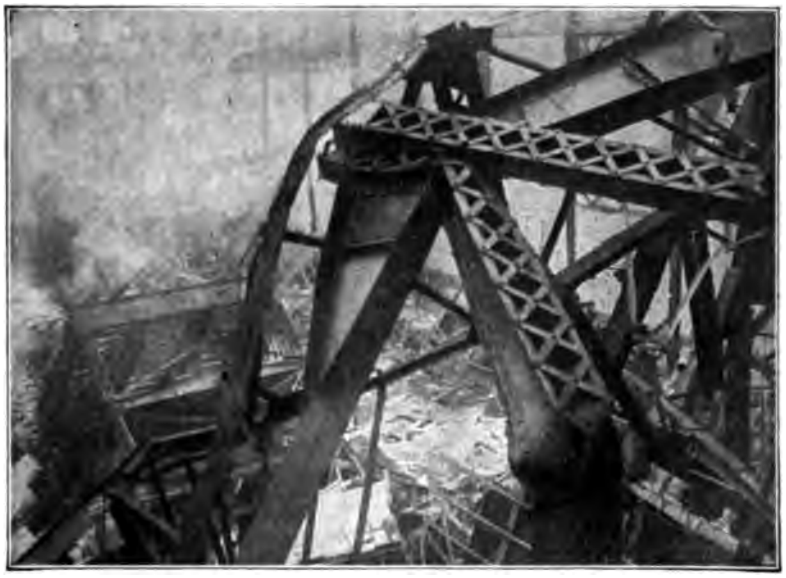


Fig. 71. Buckling of Unprotected Steel Construction Under Fire

It is a recognized fact that steel or wrought iron, when heated, will fail by buckling or bending very much sooner than the equivalent beam or post of wood, and consequently it is of importance that the steel members which are essential to the stability of the structure shall be protected by fireproofing. This protection requires that in buildings more than one story in height, the posts upon which the structure depends shall be fireproof so that a fire in a lower story may not bring down all above it. In the ordinary one-story machine shop, or buildings of a similar nature, where wide spans of trusses are necessary, the use of unprotected steel is not objectionable, but in cotton mills the use of such steel, either as columns or beams, is to be avoided if safety is to be assured and inconvenience avoided in case of fire. In any mill, the sprinklers may have their supply of water temporarily shut off, as has been the case in several large fires, and in such cases even a comparatively small fire would soon heat the steel members to a point where they would fail by bending or buckling, Fig. 71.

In buildings with wooden floors supported by steel beams, the importance of fireproofing these beams is evident if they are to be made as fire-resisting as the floors. Fig. 72 gives in detail an inexpensive method of protecting steel beams, as well as wrought-iron or steel columns when used. For the latter, however, a more substantial method is usually advisable; protection should also be provided against mechanical injury near the floor. A similar protection is applicable to rooms with wooden ceilings where quick flash fires are liable to occur; this method has long been provided for ceilings in picker and dust rooms, the metal lath being applied directly to the under side of the planking and around the beams, thus almost entirely avoiding the inconvenience of repairs after the somewhat frequent small picker-room fires.

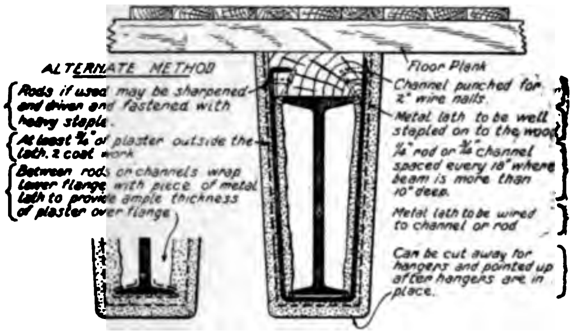

ALTERNATE METHOD
Rods if used may be sharpened and driven and fastened with heavy staple.
At least ¾" of plaster outside the lath. 2 coat work
Between rods or channels wrap lower flange with piece of metal lath to provide ample thickness of plaster over flange
Floor Plank
Channel punched for 2" wire nails.
Metal lath to be well stapled on to the wood
¾" rod or ¾" channel spaced every 18" where beam is more than 10" deep.
Metal lath to be wired to channel or rod
Can be cut away for hangers and pointed up after hangers are in place.

Fig. 72. Approved Protection for Steel Beams

REINFORCED CONCRETE MILL CONSTRUCTION

The increasing use of reinforced concrete for factory construction and its adaptability for certain classes of buildings, make it advisable to outline a few features which, from a fire protection standpoint, constitute its main advantages.

(1) Every floor above the ground floor may, by avoidance of vertical openings through them, be made practically a fire wall, and the floors being in themselves incombustible, a fire in any story may ordinarily be confined to it. In order to accomplish this, however, it is essential that stairs, elevators, and belts be placed in fireproof enclosures, with openings to each floor by fire-doors or shutters.

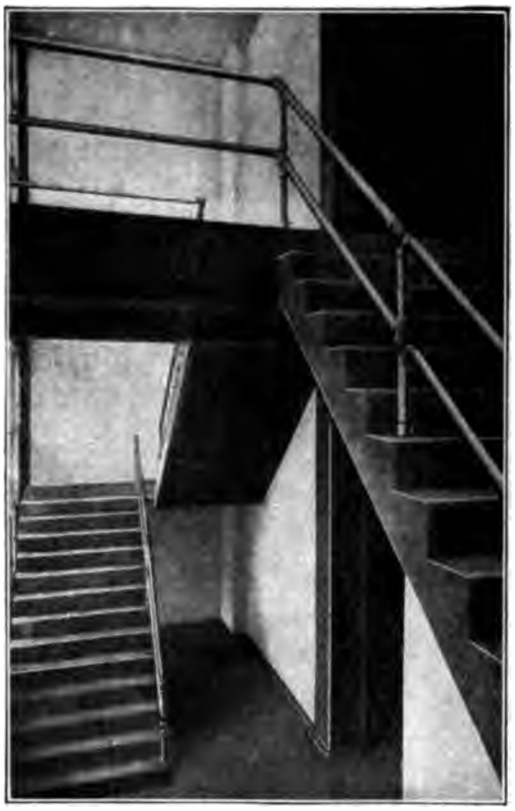


Fig. 73. Concrete Stairway

(2) If, in addition to the omission of vertical openings, provision is made for water-tight floors by using the right mixtures of good concrete and proper design and workmanship, the possibility of damage by water on floors below that in which the fire occurs is

reduced to a minimum. An essential feature of the design is the provision of scuppets of such size and form as to quickly carry outside any water upon the floors. The standard form of brick or concrete stair and elevator tower may also serve this purpose.

(3) The building, as a whole, being of incombustible material there is practically no fuel upon which a fire may feed, and even if the contents are combustible, there is less chance of a serious fire, if for any reason the protective appliances are temporarily disabled. This is a source of satisfaction to owners, in that a total loss is almost impossible.

A building of this type is very rigid and can be designed to carry heavy floor loads without deflection. This is of great advantage in connection with the use of certain kinds of running machinery requiring careful adjustment, or for heavy machinery, or for material which must be stored on floors above the first. It is not as convenient, however, for bolting down machinery or for hanging shafting.

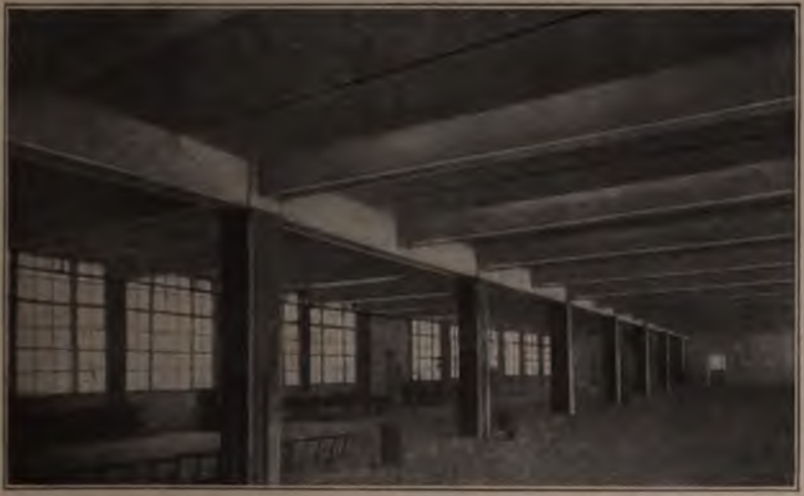


Fig. 74. Concrete Construction of the Wide Bay Type with One Line of Sprinkler Pipes in Each Bay

In the use of any of the various types of fire-resisting construction, a caution is needed to the effect that a fireproof building cannot be expected to protect inflammable contents when a fire starts, and for this reason automatic sprinklers are ordinarily needed. Therefore, an essential feature of good factory construction includes not only consideration of the building, but of protection adequate for the character of work carried on in each room. Proper and sufficient thickness of fireproofing to thoroughly protect all steel work is also necessary, and it must be substantial in its fastenings.

In the erection of reinforced concrete factories the employment of competent engineers and contractors is urged. The failure of these buildings during construction and afterward can, in almost every instance, be traced to faulty design or irresponsible builders, who, in their effort to cheapen the structure, weaken it at vital points or hasten its construction beyond a safe limit.

Four illustrations are given to show the adaptability of this construction to factory work. The stairway, Fig. 73, is also applicable to the factory with timber floors, furnishing a safe and ready means of exit. Such stairways are required by the ordinances of many cities. Fig. 74 illustrates the application to the ordinary factory building of the wide bay type, with one line of sprinklers through the center of each bay. Figs. 75 and 76 illustrate its application to saw-tooth construction, the interior view being of special interest as emphasizing the great value of the saw-tooth form of skylight in diffusing the light uniformly over the entire floor area.

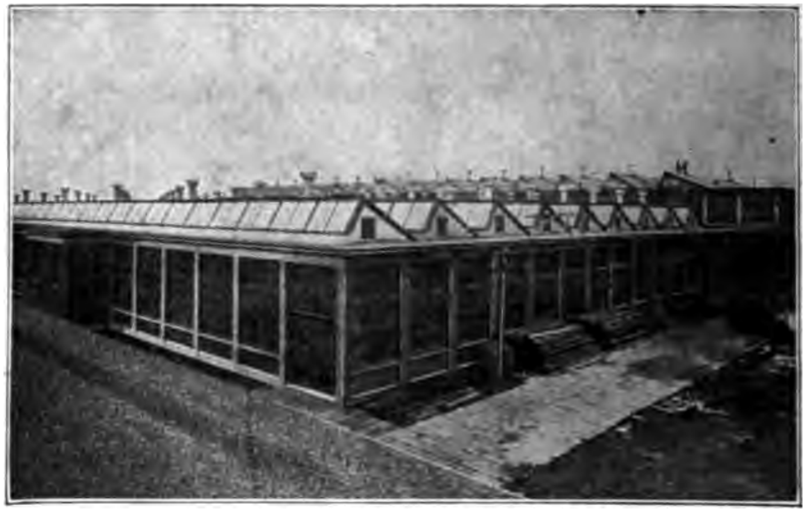


Fig. 75 Exterior View of Saw-Tooth Roof Construction

FIRE WALLS AND FIRE CURTAINS

In the application of the recognized principles of fire protection, engineers, architects, and factory managers must not neglect the consideration of the area over which a single fire may be communicated. Experience has shown that fire may extend from one building to another across an intervening space if walls are not incombustible and window openings are not adequately protected; hence, the desirability of good distance between buildings is clear especially if they are of several stories in height. The necessity of light and air also requires this, but in one- and often in two-story buildings these last considerations do not ordinarily apply, and the tendency has been to erect one-story buildings of considerable height and extended area, and with roofs of very combustible construction through which a fire might readily sweep, involving the entire structure. Such fires not only indicate the need of automatic sprinklers in plants of this character, but show the necessity for subdivision of large areas by fire stops.

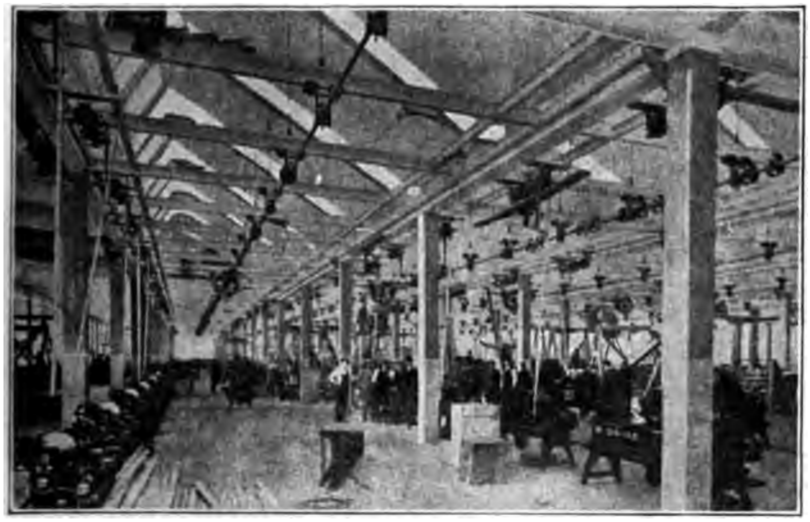


Fig. 76. Interior View of Saw-Tooth Roof Construction

In the design of new plants or extension of old ones, due regard should therefore be given to the arrangement, so that hazardous processes may be separated from the main values, and large areas or values be reasonably subdivided by substantial fire walls extending through the roofs. The possibility of a single fire wrecking the entire plant is thus ordinarily avoided.

Areas need to be of proper size for economical shop management, but there is a limit beyond which there is no gain and perhaps on the contrary a distinct disadvantage. Cases may be cited where a needed fire wall has been omitted for no other reason than to save the cost of the wall itself.

A device called a *fire curtain*, Fig. 77, which is adapted for use in large roofs over areas which now cannot be otherwise subdivided, is installed between the sections of a sprinkler system so that the heads on either side may be fed by independent risers. These curtains, with the assistance of the fire apparatus, will prevent a fire extending rapidly through a roof and will confine the fire to much smaller areas, thus opening a smaller number of sprinklers, preventing the overtaxing of the water supply, and at the same time lessening the damage by water.

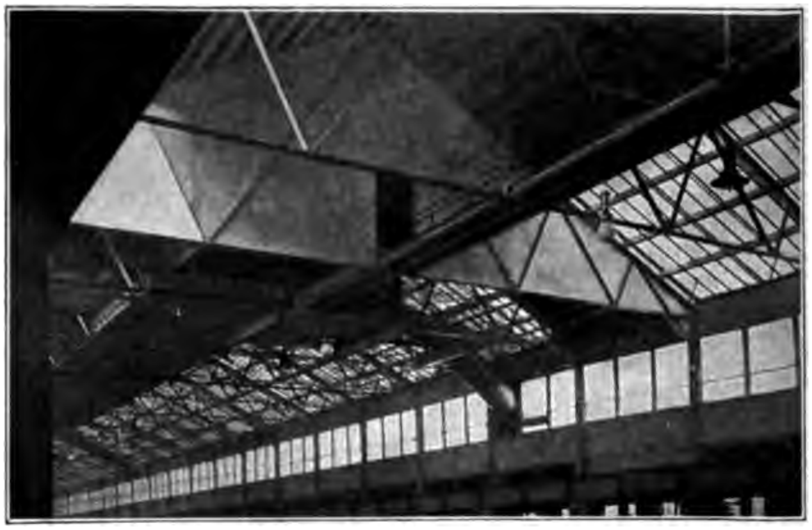


Fig. 77. Fire Curtain

Fire curtains must be substantially erected and it is of importance that they fit tightly at the roof in order that fire or heat may not pass over them at this vital point. They may be built of metal lath with cement plaster, or of galvanized or corrugated iron, and are best fastened directly to the side of one of the trusses and to angle iron secured to the under side of the roof plank.

ONE-STORY STOREHOUSE OF MILL CONSTRUCTION

The best modern practice in the construction of one-story compartment storehouses, Fig. 78, intended primarily for storage of cotton, but adapted for other stock in bales or cases, is as follows:

Construction. *Compartments.* The area of each compartment should not be over 10,000 square feet for non-hazardous storage, nor more than 5,000 square feet for cotton.

The height should accommodate one bale standing on end with good clearance space above, to provide for distribution of water from sprinklers, or to allow cased goods to be piled two high without coming up between the beams, should it be desired to use a section wholly for this purpose. Nothing should ever be piled between the beams or within a floor of the under side of them, because of the interference with the distribution of water and the liability of the sprinkler pipes being struck and bent or broken from their fastenings.

Each section as designed has a capacity of 600 bales of cotton on end or corresponding quantities of other stock.

Walls. The compartments should be separated by brick fire walls 12 inches thick extending not less than 2 feet above the roof and provided with a vitrified coping laid in cement mortar at the top. There should be no doorways in these division walls.

The side walls should be of brick 8 inches thick reinforced by 12-inch pilasters. Solid 12-inch walls throughout would be a little more substantial and not much more expensive. All door openings should have round-nosed bricks at the edges.

Floors. The floors of concrete, pitched slightly to the doors, should be laid some distance above the natural surface of the ground. In case the ground is wet, open tiled drains should be laid around the edges of the compartment inside the foundation, and tar concrete used for the floor material.

Roofs. The roofs should be built of plank and timber supported on substantial posts having the corners rounded, Fig. 79. It is often advisable to sheath these posts with iron about 3 feet high from the floor to protect them from trucks. In no case should

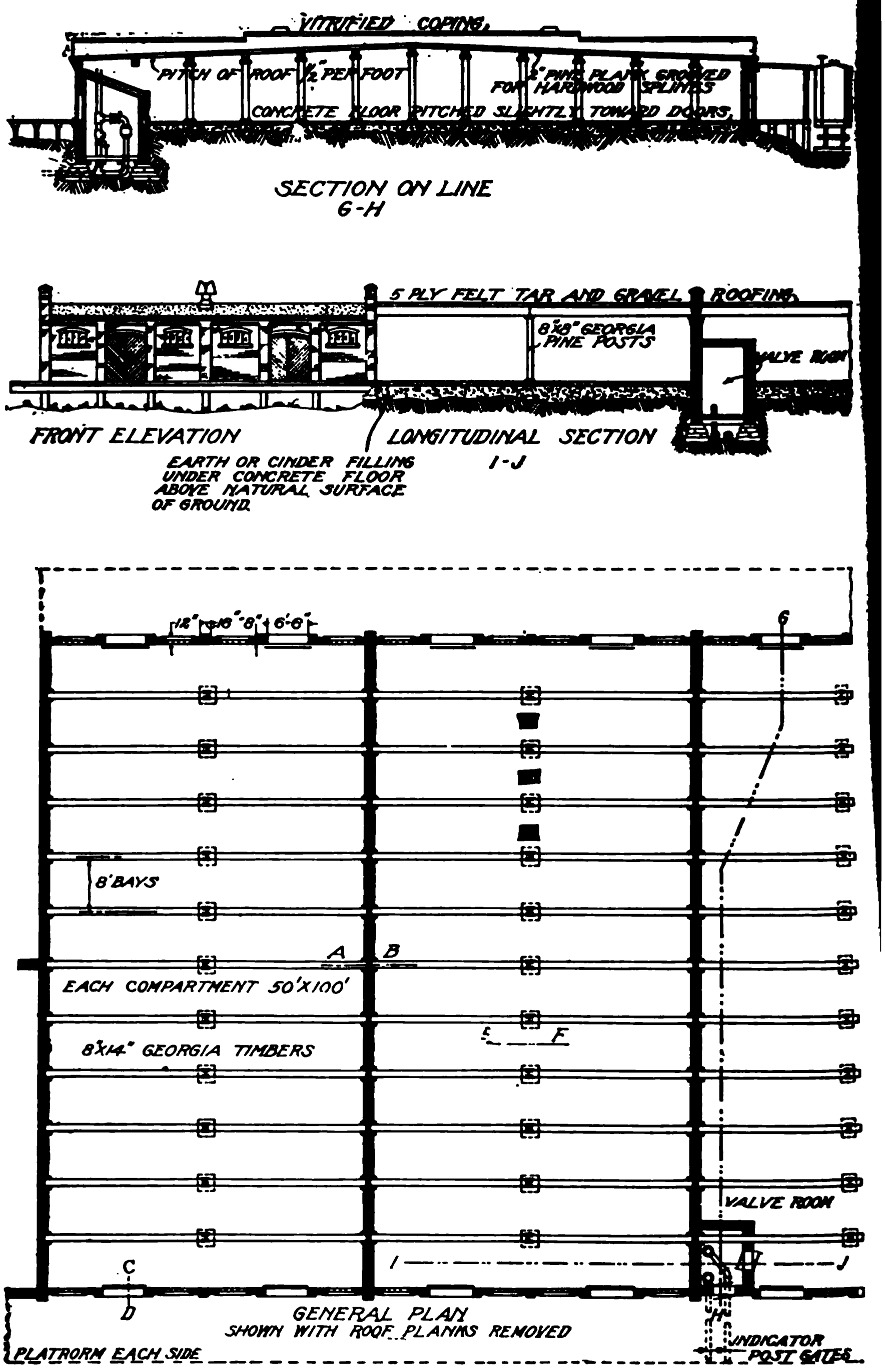
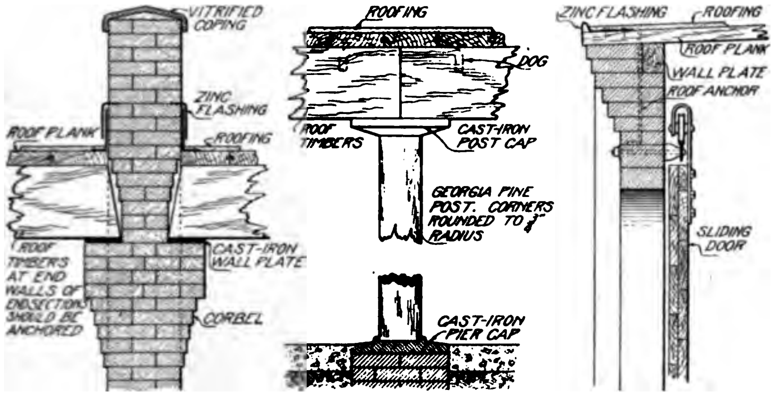

VITRIFIED COPING
PITCH OF ROOF ½" PER FOOT
2" PINE PLANK GROOVED FOR HARDWOOD SPLINES
CONCRETE FLOOR PITCHED SLIGHTLY TOWARD DOORS.
SECTION ON LINE G-H
5 PLY FELT TAR AND GRAVEL ROOFING
8"x8" GEORGIA PINE POSTS
VALVE ROOM
FRONT ELEVATION
LONGITUDINAL SECTION I-J
EARTH OR CINDER FILLING UNDER CONCRETE FLOOR ABOVE NATURAL SURFACE OF GROUND
12" 16" 8" 6'-6"
G
8' BAYS
A
B
EACH COMPARTMENT 50'X100'
8"x14" GEORGIA TIMBERS
E
F
VALVE ROOM
C
D
I
J
H
GENERAL PLAN SHOWN WITH ROOF PLANKS REMOVED
PLATFORM EACH SIDE
INDICATOR POST GATES

Fig. 78. Plan and Sections of a One-Story Compartment Storehouse of the Best Mill Construction

timber less than 6 inches in thickness be used, as very light beams are readily combustible and even a slight charring takes away a large proportion of their strength. The roof covering should be 5-ply felt tar and gravel and substantial zinc flashing should be used where necessary. The galvanized iron ventilators should be of such design as to prevent the entrance of sparks from exposures.

Windows. The windows should be placed as high as possible and have wooden frames glazed with common glass. These sashes should be hinged at the bottom to swing inward and provided with chains and catch. Doors and windows need special protection if there are exposures.

Protection. *Automatic Sprinklers.* A standard equipment of automatic sprinklers should be installed in each section. If the building can be heated slightly, the water may be kept on the sprinklers throughout the year, but if there is danger from freezing, an air system with the water controlled by an approved dry-pipe valve must be used. All pipes must have at least ½-inch pitch per 10 feet, back to the main riser to insure proper drainage.



SECTION THROUGH A-B SECTION THROUGH E-F SECTION THROUGH C-D

Fig. 79. Roof Construction in Detail of the Storehouse Shown in Fig. 78

The number of heads in each section of this size (50×100 feet) is such that five compartments may be controlled by one dry-pipe valve located in the middle section. The valve room is built low in the ground with double walls, roof, window, and door, to prevent entrance of frost, and in the colder climates artificial heat, such as

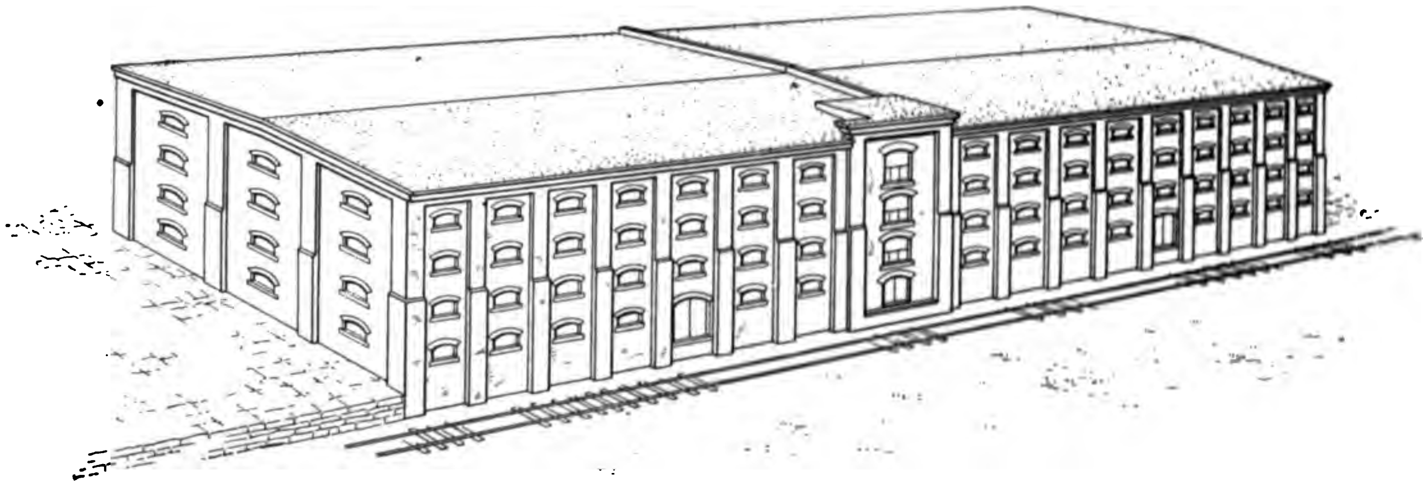


Fig. 80. Exterior View of Four-Story Mill-Constructed Storehouse

steam or an electric heater, is advisable. In mild climates, it is usually preferred to run a line or two of steam pipe overhead in each section of the storehouse for use in the few cold days, and

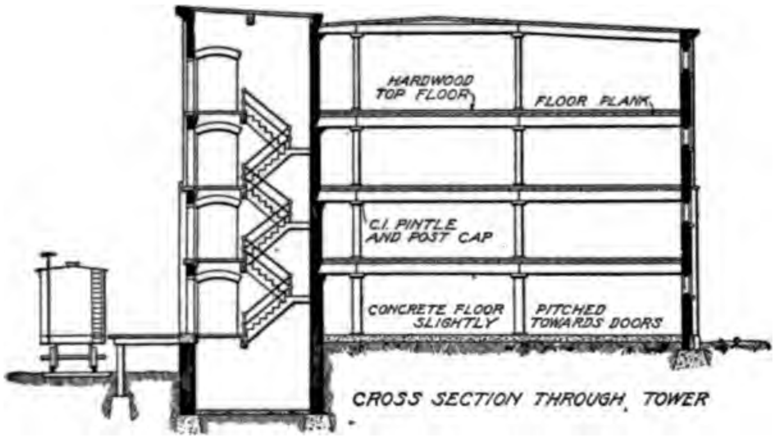


Fig. 81. Vertical Section of Fig. 80 Showing Stairways Isolated in a Tower

thus avoid the expense of installation and maintenance of a dry-pipe valve. The protection by this method is much superior.

The water supply for the sprinklers as well as for such outside

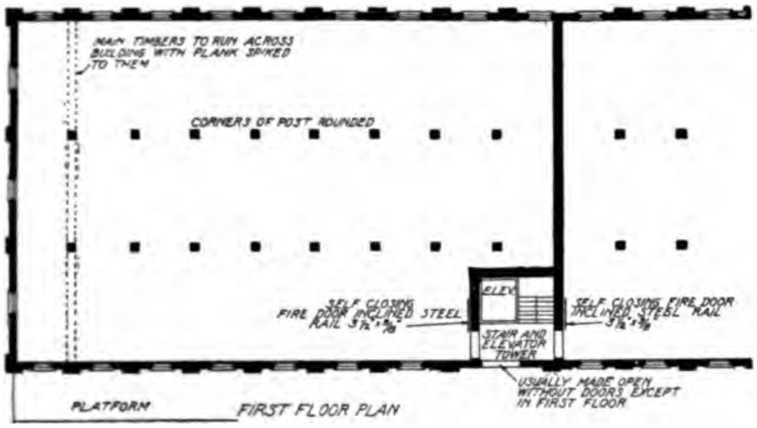

MAIN TIMBERS TO RUN ACROSS BUILDING WITH PLANK SPIKED TO THEM
CORNERS OF POST ROUNDED
ELEV.
SELF CLOSING FIRE DOOR INCLINED STEEL RAIL 3½×⅝
SELF CLOSING FIRE DOOR INCLINED STEEL RAIL 3½×⅝
STAIR AND ELEVATOR TOWER
USUALLY MADE OPEN WITHOUT DOORS EXCEPT IN FIRST FLOOR
PLATFORM
FIRST FLOOR PLAN

Fig. 82. Floor Plan of Fig. 80

hydrants as may be needed should be of good capacity, preferably from two independent sources.

FOUR-STORY STOREHOUSE OF MILL CONSTRUCTION

The best practice in the construction of a storehouse more than two stories in height, Figs. 80, 81, 82, and 83, intended for storage of raw stock or goods, is as follows:

Construction. *Compartments.* The area of each compartment should be preferably 5,000 square feet, and not over 10,000 square feet for non-hazardous storage; 5,000 square feet is the usual standard for cotton.

The height for each story for cotton or for other inflammable material should be such as to permit the storage of but one bale on end—8 feet from floor to floor is generally sufficient. When designed for cased goods, the height should be sufficient to take two cases with 10 inches to 12 inches to spare under the beams in order not to impede the distribution of water from the sprinklers. Ample provision for passageways should also be made.

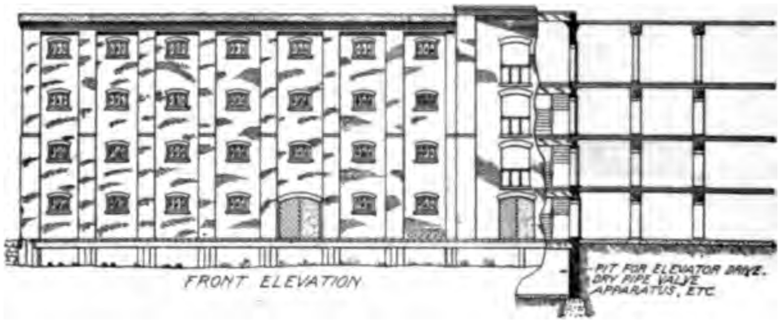


Fig. 83. Elevation and Part Section of Fig. 80

The compartments should be separated from each other by solid brick walls and be accessible only from the elevator and stair tower, with the openings to the latter protected by standard automatic sliding doors. This will confine damage to the compartment in which a fire may start.

Walls. Brick walls should be at least 12 inches thick in the top stories and increased at the lower floors to support their additional load. The pilastered wall has many favorable features and is preferred to the plain solid form. Window and door arches should be of brick; window and outside door sills and underpinning should be of granite or concrete.

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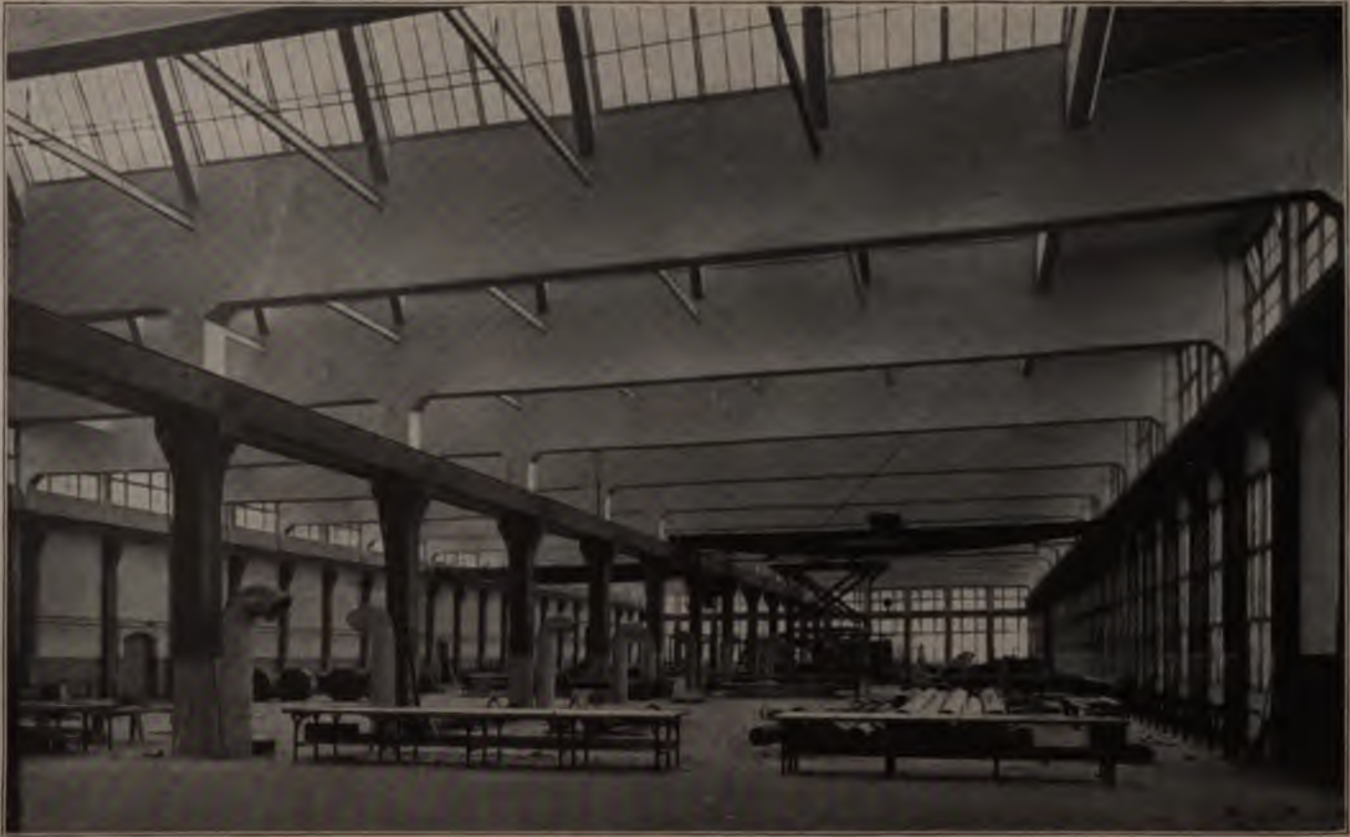

INTERIOR OF ASSEMBLY BUILDING OF THE GEORGE N. PIERCE COMPANY, BUFFALO, N. Y.

Spans under the sawtooth roof are 61-ft., giving the building two unbroken bays, each 61 ft. by 401 ft. Kahn System of Reinforced Concrete. *Courtesy of Trussed Concrete Steel Company, Detroit, Mich*

Roofs. Roofs should be of 3-inch pine plank, spiked directly to the heavy, roof timbers and covered with 5-ply tar and gravel roofing. Roof should pitch ½ inch to the foot. Conductor pipes should not pass through the building unless the storehouse is to be heated in winter. An incombustible cornice is needed when there is exposure from neighboring buildings. The fire wall should be carried 2½ feet above the roof, and provided with vitrified coping laid in Portland cement mortar.

Floors. There must be no vertical openings through floors except in the tower, so that fire cannot gain access to one floor from another without burning through the solid plank floor.

Floors should be of spruce plank 3 inches, or 4 inches, or more, in thickness according to the floor load and should be spiked directly to the floor timbers. In floors and roof the bays should be from 8 to 10½ feet wide and all plank should be two bays in length laid to breach joints every 4 feet and grooved for hardwood splines. The plank at the walls should be left out until the windows are put in to prevent damage from swelling in case of rain.

The top floor should be of maple or other close-grained hardwood. The floor and roof timbers should be sound Georgia pine in single sticks, if possible; if it is found necessary to use double beams, they should be bolted together without air space between. Timbers should rest on cast-iron plates or beam boxes in the walls and on cast-iron caps in the columns. At least a half-inch air space should be left around all beams built into the masonry. Columns of Southern pine should be cut with their ends square with the axis.

Windows. Windows may be of small area, but should be placed high in order to give the best light.

Protection. *Sprinklers.* A standard equipment of automatic sprinklers should be installed throughout. In mild climates and under some conditions in cold ones it is advisable to install on each floor a line of 1¼-inch steam pipe overhead to provide sufficient heat to prevent freezing of the water in the sprinkler pipes. If the building is not heated, an air system with water controlled by an approved dry-pipe valve must be used and all pipes must have a half-inch pitch per 10 feet back to the main riser to insure proper drainage. A dry-pipe valve chamber may be located in the basement of the stair tower. The number of sprinklers on one dry-pipe valve should preferably not exceed 300, and 400 is the maximum allowed under these rules. By heating the storehouse, the expense of installation and maintenance of the dry-pipe system is avoided, and in buildings of this substantial character only a very small amount is needed, as the temperature need be kept only a little above the freezing point.

Standpipes. Standpipes are often advisable in the stair towers of the higher storehouses and provision should be made below frost for draining them in cold weather, with a readily-accessible indicator post gate for controlling the supply in case of emergency.

Water supply for the sprinklers and standpipes as well as for such outside hydrants as may be needed should be of good capacity from two independent sources.

ONE-STORY WORKSHOPS OF MILL CONSTRUCTION

For workshops on cheap, level land, especially where the stock is heavy, one-story buildings have proved to be more economical in cost of floor area, supervision, and moving stock in process of manufacture; machinery can also be run at greater speed and with less repair than in high buildings. While the saw-tooth form of roof may not always be necessary or advisable, an outline is herewith given of a type common for machine shops, foundries, and similar occupancy where increased head room is required and traveling cranes used, Figs. 84 and 85.

Construction. The center section over the crane is often provided with saw-tooth skylights with excellent results, and in others the side bays are made higher for a gallery. These buildings are readily warmed and ventilated, and the heavy plank roofs are free from condensation in cold weather. Window areas should be as wide as practicable and extend as high as possible. Forced circulation of heated air is very desirable with overhead steam pipes.

Roofs. The principles of standard mill construction should be followed- Trusses in roofs are ordinarily from 8 to 20 feet on centers, the 3-inch plank spanning the distance between the trusses, or resting on purlins not less than 8 feet on centers and running longitudinally. It is important that monitors be of substantial plank construction with wide bays as in the main roofs.

The cornice is of the overhanging type with drip outside without gutters. The internal gutters are preferred, as an outside

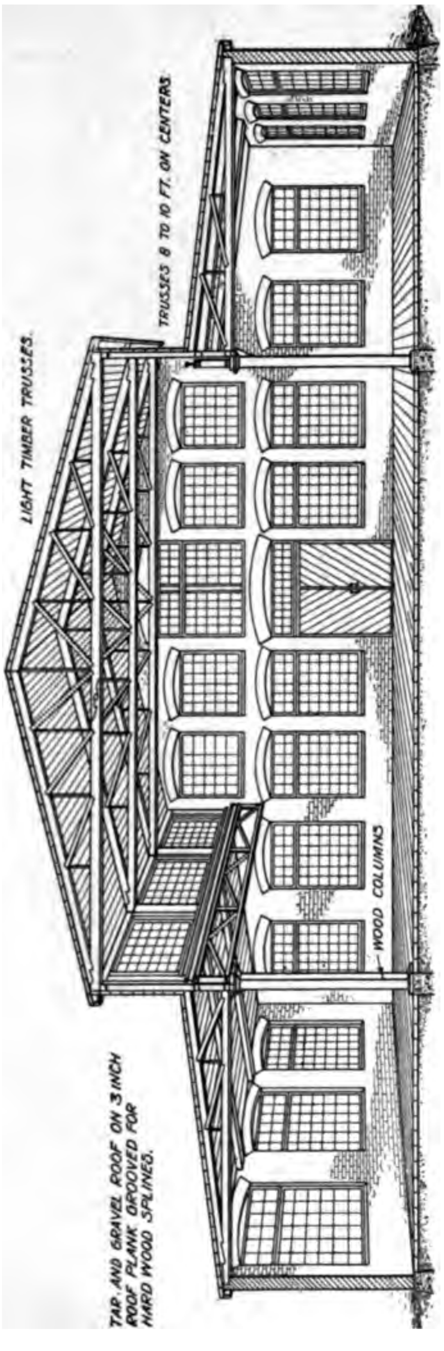
LIGHT TIMBER TRUSSES.
TRUSSES 8 TO 10 FT. ON CENTERS.
WOOD COLUMNS
TAR AND GRAVEL ROOF ON 3 INCH ROOF PLANK GROOVED FOR HARD WOOD SPLINES.

Fig. 84. Design for Mill-Constructed Workshop with Pitched Roof

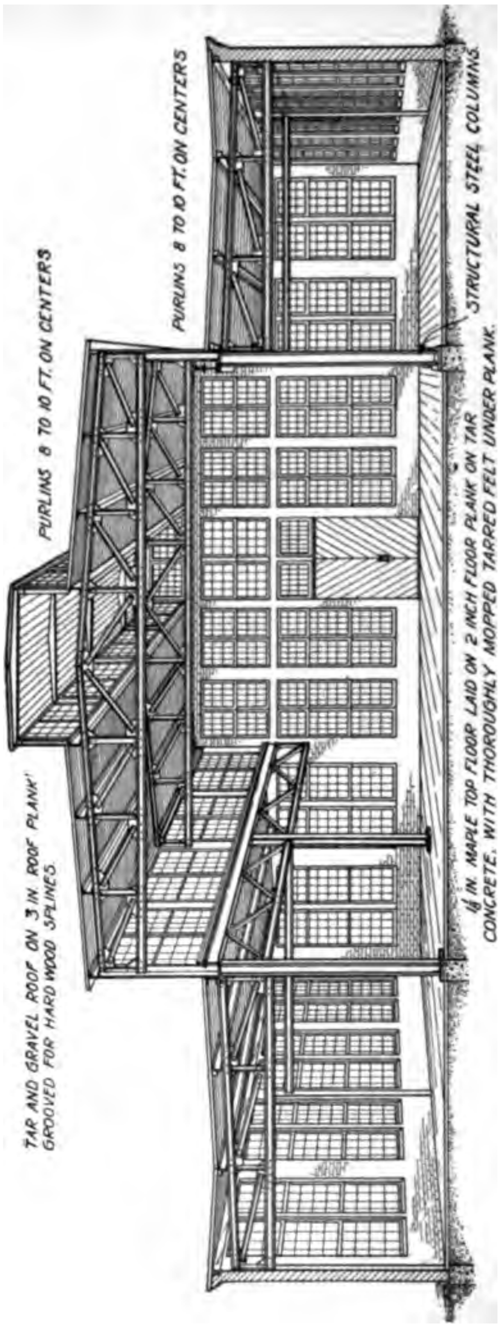
TAR AND GRAVEL ROOF ON 3 IN. ROOF PLANK GROOVED FOR HARD WOOD SPLINES.
PURLINS 8 TO 10 FT. ON CENTERS
PURLINS 8 TO 10 FT. ON CENTERS
1⅛ IN. MAPLE TOP FLOOR LAID ON 2 INCH FLOOR PLANK ON TAR CONCRETE, WITH THOROUGHLY MOPPED TARRED FELT UNDER PLANK.
STRUCTURAL STEEL COLUMNS.

Fig. 85. Design for Mill-Constructed Machine-Shop Adapted for Traveling Cranes

drip is often objectionable. When in locations exposed by other buildings of hazardous construction or occupancy, parapeted brick walls and cornices are needed.

Floors. If earth or cement floors are not suitable, wood floors should be laid as follows: Make a bed of broken slag or stone several inches thick and thoroughly rolled, upon which put a 4-inch layer of tar concrete and on this 1 inch of asphalt evenly rolled. On this lay 2-inch or 3-inch hemlock planks bedded in hot pitch, and over them a $\frac{7}{8}$- or $1\frac{1}{8}$-inch maple floor at right angles to the plank.

Protection. *Sprinklers.* This type of wide bay construction is adapted to economical installation of a sprinkler equipment as the minimum number of heads are required, thus keeping down the cost.

Appliances. The usual outside fire-protection appliances are, of course, to be provided.

SAW-TOOTH ROOF CONSTRUCTION

The great advantages and the increasing use of saw-tooth roof construction, as well as the lack of familiarity with it at many factories, make it desirable to outline its important features.

Specifications. Two typical designs are illustrated—Fig. 86 showing a textile weave shed with good basement for the shafting with which to drive the looms on the main floor, thus dispensing with the overhead shafting and belting in the weave room; Fig. 87 showing a design for a light machine-shop or foundry. Other designs with light wooden trusses or with reinforced concrete construction are equally desirable.

It may be well to state that the light roof of 2-inch and 3-inch joists and boards should never be used. Furthermore, while slow-burning or mill construction, with heavy timbers, is preferred, the increasing cost and difficulty of promptly obtaining yellow pine lumber of good dimensions, often necessitates the use of trussed forms, using rather light timbers; in every case, however, they should be not less than 6 inches in width and of a depth sufficient to carry the load—this in order that they may be "slow-burning." The roof in all cases should be of plank with wide bays.

The adaptability of the light forms of steel for framing trusses, especially when wide spans are needed, often compels their use, and, in plants having safe occupancy such as metal workers, these are not

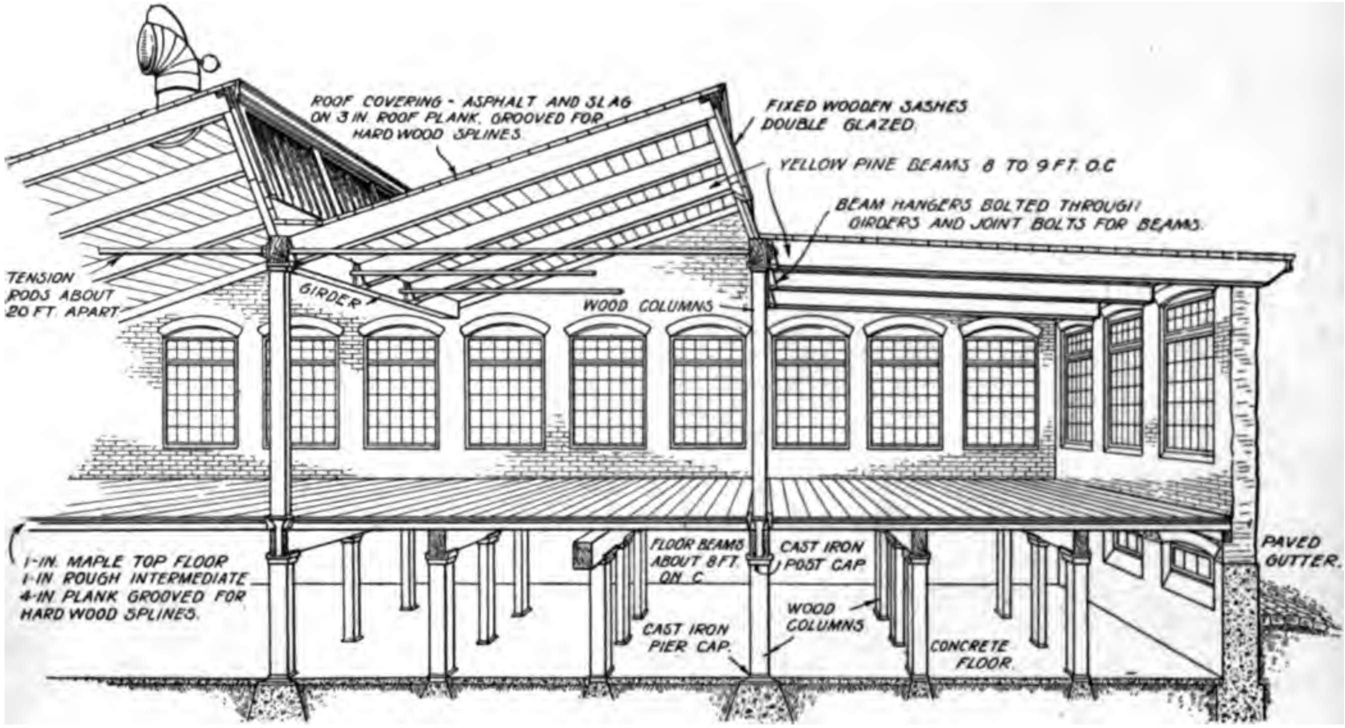
ROOF COVERING - ASPHALT AND SLAG ON 3 IN. ROOF PLANK, GROOVED FOR HARD WOOD SPLINES.
FIXED WOODEN SASHES DOUBLE GLAZED.
YELLOW PINE BEAMS 8 TO 9 FT. O.C.
BEAM HANGERS BOLTED THROUGH GIRDERS AND JOINT BOLTS FOR BEAMS.
TENSION RODS ABOUT 20 FT. APART
GIRDER
WOOD COLUMNS
1-IN. MAPLE TOP FLOOR
1-IN. ROUGH INTERMEDIATE
4-IN. PLANK GROOVED FOR HARD WOOD SPLINES.
FLOOR BEAMS ABOUT 8 FT. ON C.
CAST IRON POST CAP.
PAVED GUTTER.
WOOD COLUMNS
CAST IRON PIER CAP.
CONCRETE FLOOR.

Fig. 86. Vertical Section of Saw-Tooth Roof Construction for Textile Weaving Shed

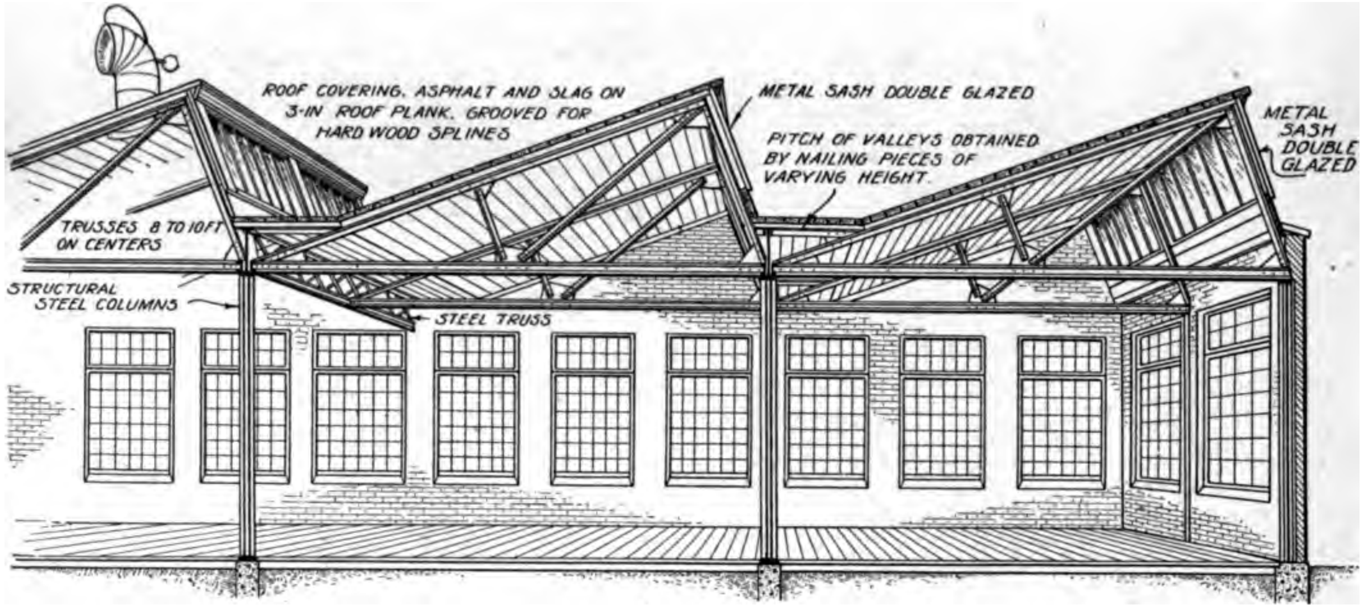

Fig. 87. Vertical Section of Saw-Tooth Roof Construction for Light Machine-Shop or Foundry

objectionable, providing adequate sprinkler protection with good water supply is available to prevent quick failure of the steel work, due to heat from combustion of contents or roof. Similar protection, of course, is needed in shops with wooden trusses if disastrous fires are to be prevented, but experience has shown that the steel-trussed roof will fail much quicker than one of wood under similar conditions. Wooden posts are nearly always available and should be given the preference, but if light steel columns are used, they should be well protected by insulating materials if in rooms containing combustibles, as the column is the vital part of the roof support.

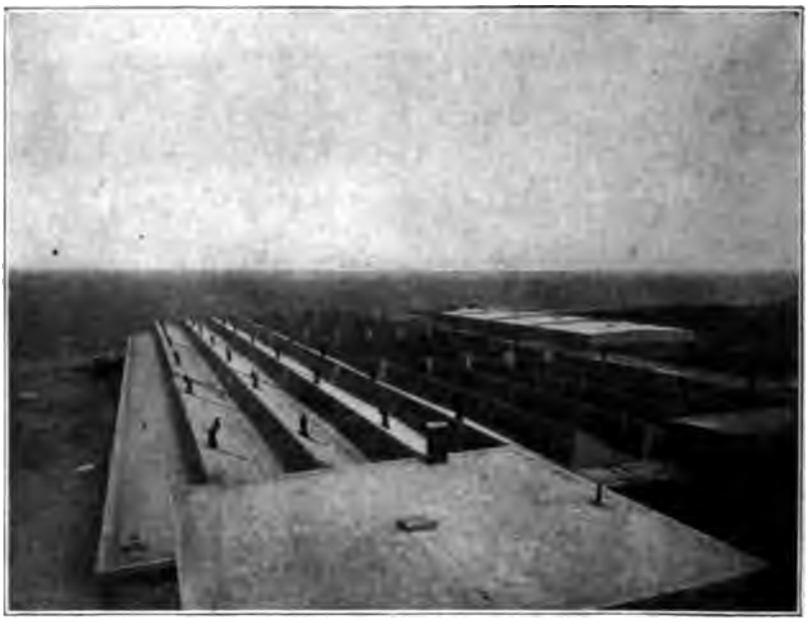

Fig. 88. Excellent View of Saw-Tooth Roof Construction

Advantages of Saw-Tooth Roof. (1) Uniform diffusion of light throughout the room, thus making all space available. With all interior surfaces painted white and with ribbed glass in the sash the diffusion of light is almost perfect.

(2) Adaptability for lighting large floor areas in wide buildings with low head room compared to what is necessary in wide buildings with the ordinary form of monitor skylights.

(3) Offers the true solution to the problem of excluding the direct rays of the sun and obtaining the very desirable north light.

(4) Economy in lighting, in that it lessens the fixed charges by decreasing the number of hours during which artificial light is necessary.

(5) Better working conditions, especially in textile mills, therefore increasing production and encouraging permanency of the help.

(6) Especially adapted to weaving and similar processes in textile factories, Figs. 88 and 89; machine-shops; foundries doing light work, and similar work, such as assembling and drafting; and in some dye-houses where careful matching of colors is necessary.

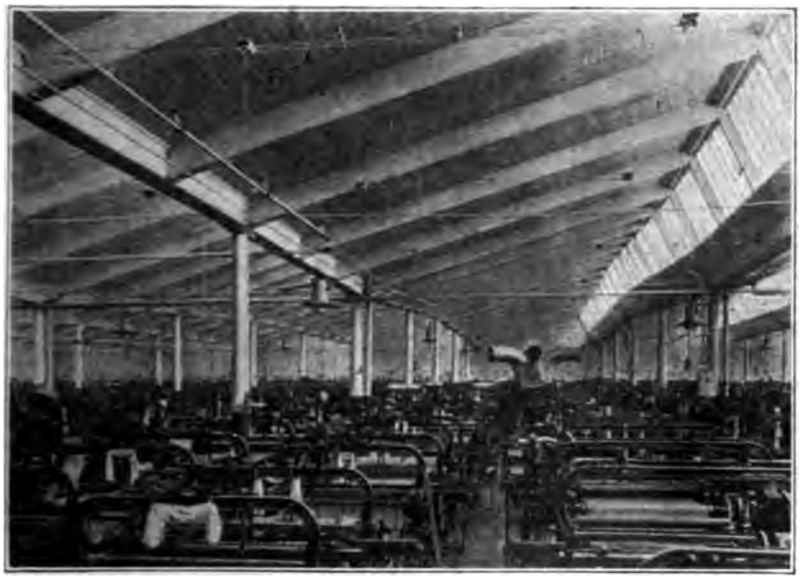

Fig. 89. Interior View of Cotton Mill with Saw-Tooth Roof Construction

Disadvantages of Saw-Tooth Roof. While testimony of those having had experience with saw-tooth roofs is almost uniformly favorable, more or less difficulty has been experienced, practically all of which may be considered as due either to faulty design or poor workmanship. The difficulties in general are caused by leaks due to severe conditions during winter in our northern climates, poor ventilation, excessive heat when roofs are thin, or excessive condensation on under side of roof and glass when the temperature outside is low and there is considerable moisture in the rooms.

Suggestions. The following suggestions show how these difficulties may be obviated if applied to special cases by competent engineers or architects. What is good engineering from the view-point of the manufacturer can also be good engineering from the view-point of fire protection, and any design should be adapted to both, if the best interests of the manufacturer are to be served.

(1) It being desirable to avoid direct sunlight and at the same time obtain abundance of light perfectly diffused, the saw-teeth should face approximately north and the glass should be inclined to the vertical in order to take advantage of the brighter light in the upper sky and to prevent the cutting off of the light by the saw-tooth immediately in front, and above all to show the diffusion of the light upon the floor rather than on the under side of the roof planking.

(2) The glass should make an angle of 20 to 25 degrees with the vertical, and an angle of approximately 90 degrees at the top of the saw-tooth, the variations to depend upon the latitude and the amount of light required. A sharper angle at the top is detrimental, as it increases the cost by increasing the spans and the amount of roof to cover; more glass is also required in proportion and the light is not as good, more sky light being lost and too much being thrown on the under side of roof.

(3) Double glazing with space between is preferred on account of its conducting qualities, but is not always necessary except in the north country. The inside glazing should be factory-ribbed glass, with ribs vertical and inside; shadows cast by trusses are then almost unnoticeable.

(4) Condensation gutters are needed on the inside at the bottom of the sash and they should be drained through inside conductors and not to the outside under bottom of the sash, as these latter admit cold air and are liable to freeze.

(5) Valleys between the saw-teeth should be flat, 14 inches to 2 feet in width and pitched ½ inch per foot toward the conductors, which should be of ample size, and not much over 50 feet apart—preferably less. The necessary pitch may be obtained by cross-pieces of varying heights on top of the trusses, thus avoiding hollow spaces.

(6) Leaks, a common fault, may ordinarily be prevented by careful design of gutters, valleys, and sashes, and by insisting on good workmanship and materials. The roof covering of asphalt or pitch should be continuous through the valleys and extend up to the glass. We illustrate one form of construction understood to have been very satisfactory, Fig. 86, and in connection with it refer to the papers and discussion on Saw-Tooth Roofs in Transactions A. S. M. E., Vol. XXVIII, 1907, which contain much of value.

(7) Experience has demonstrated the advantage of a combination of direct radiation with a fan sufficient only for ventilation and tempering the room. Heating pipes should usually be placed overhead and directly under the front of the saw-teeth, and should run the entire length, so as to assist in preventing condensation. Where there is no moving shafting some forced circulation is necessary, and is best obtained by fan, often driving air from a dry basement or outside as required, and discharging it over heating coils to the floor above. In weave and similar rooms this is especially necessary and advantageous in promoting health and comfort of employes, making greater efficiency possible. Ventilation and cooling of these large areas with comparatively low stories must not be neglected. Ample vents are needed at the top in the shape of large metal ventilators with double walls and tight dampers. They are recommended instead of pivoted or swinging sash, which are apt to leak in driving storms and when open allow dirt to blow in off the roof. Good windows are advised in side walls and experience has shown their value.

(8) Framing of the saw-teeth may be in timber, steel, or reinforced concrete. The design should be such as to obstruct the light as little as possible, strong enough to hold wet snow without sagging, and stiff enough to carry shafting motors, etc., when they are to be overhead. When wood or steel is used, the roof planking should be 3 inches or over, spanning wide bays of 8 to 10 feet.

Hollow spaces in roofs should not be permitted. They are very undesirable from a fire standpoint, and any condensation which may take place in them during cold weather soon rots both plank and sheathing.

Sheathing, even without spaces behind it, is a more or less bad feature, and it is readily combustible; if used, however, it should be applied directly to the under side of the roof plank, with only a layer of some insulating material between, so that there may be no concealed space. If 3-inch plank is sufficient for a flat roof, it should be for a saw-tooth, and with good circulation of air there should be no trouble except in wet rooms, where condensation is bound to occur whether under a roof or the floor of the room above, unless large quantities of dry air are discharged into the room.

Saw-tooth roofs necessarily cost more, as there is practically the same amount of roofing as in flat roofs, and in addition there is the cost of windows, glazing, flashing, conductors, condensation gutters for the skylights, and a somewhat larger cost of heating. The additional cost of these items does not, however, fairly represent comparative cost, as there should be considered the total cost of the building compared with an ordinary one of stories sufficiently high and narrow enough to give the required light. When all of these things are considered, the slight additional cost is far outweighed by advantages of the type for work where good light is desirable.

FIRE INSURANCE INSPECTION

PART III

PRIVATE FIRE PROTECTION

AUTOMATIC SPRINKLERS

History. Sir William Congreve, an English engineer, who in 1812 patented an early type of sprinkler, described it in his patent papers as "an apparatus for extinguishing fires which shall be brought to bear upon the precise part where the flames exist." After a century of development the modern sprinkler accomplishes with wonderful reliability and success what his device professed to do. Previous to his time there had been put into operation many schemes for automatically extinguishing fires; that is, devices by which the fire itself or the heat from it released a chemical or a stored supply of water by which the flames themselves were then put out. As early as 1723 a man named Godfrey invented one such system in which lines of fuses led to a pewter chamber of gun powder within a cask of extinguishing fluid. This was tried in London and reported successful.

In 1806 John Carey patented a system in which open nozzles were attached to empty lines of pipe extending from an elevated tank. Weighted valves held closed by combustible cords kept the water out of the pipes until it was needed and released by a fire. The most evident drawback to this scheme was the general distribution of the water over large areas instead of its being confined to the seat of the trouble. Congreve's sprinkler, as his definition shows us, was designed to overcome this fault. His form of nozzle was held closed by cement which was supposed to fuse at 110°F., this device showing a great advance over previous attempts.

Some of the problems yet unsolved were—

(a) The proper distribution of the water discharged.

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(b) The making of the head reliably certain in action and yet tight and strong enough to prevent leakage or rupture of the solder joint.

(c) The location of the fusible solder so that the flow of cold water through a partly opened orifice would not chill the solder below the melting point, and thus prevent the entire opening of the sprinkler.

(d) The making of a permanent solder which should have a sufficiently low melting point.

(e) The protection of the sprinkler head against corrosion and incrustation. This last has proven the most difficult problem and even at the present time, although there are many protective devices and preparations, much in this line remains to be done.

Parmelee Sprinkler. In spite of so early a beginning it was not until 1874 that any sprinkler head was perfected sufficiently to be sold for practical purposes. This first commercial sprinkler was manufactured and sold by Parmelee of New Haven, Conn., and the use of this sprinkler was rapidly adopted, for here in New England the need of such an automatic sprinkling device was seriously felt in the cotton mills where hazards were great, and premiums and losses large.

Since then the automatic sprinkler has been developed rapidly. Some of the men who have been prominent in this field since Parmelee are Barnes, Bruce, Esty, Gray, Grinnell, Harkness, Kane, Neuracher, Walworth and many others.

MODERN SPRINKLERS AND THEIR INSTALLATION

Principle of Action. In general the modern sprinkler head or sprinkler valve consists of a one-half inch orifice, a few inches from which is a deflector or "splash plate." The stopper of this orifice is held in place by a series of metal pieces held together by fusible solder, and so arranged that they form a strut or brace between the stopper and the deflector.

A slight rise in temperature, due, say, to a fire, would cause the solder to melt, the brace then drops apart and releases the stopper and the water escaping strikes the deflector which breaks it into a shower that descends upon and extinguishes the fire. One sprinkler head can wet a floor area of from 50 to 100 square feet.

Solder. The solder now used is practically the same in the various heads and consists of an alloy of bismuth, cadmium, and lead. Other formulas and combinations of metal have been tried but have not been successful, one containing mercury having been used in some of the early types. The present solder melts between 155°F. and 165°F., alloys of lower fusing point having been found after many experiments to be unreliable.

In order to be approved and accepted by the National Board of Underwriters a sprinkler head must pass the following test and meet the following requirements:

NATIONAL BOARD REQUIREMENTS FOR SPRINKLER HEADS

A sprinkler head when open must have an unobstructed outlet of such size that with but 5 pounds pressure it will be able to discharge at least 12 gallons a minute.

When new it should not leak under a test of 300 pounds hydraulic pressure, nor should it burst or leak when the pressure is suddenly raised from 0 to 300 pounds, five hundred or more times consecutively.

The solder used in the sprinklers designed for ordinary use should not melt below 155°F. but should melt below 165°F. The solder for the so called hard heads used in boiler rooms, drying rooms, and wherever the normal temperature is above 165°, must fuse at some point between 275 and 300 and this fusing point must not change with age.

Although in use it is best that sprinkler heads be attached to the pipe in an upright position to prevent the collection of sediment in them, they must be designed to operate satisfactorily in either a pendant or upright position; and in either position with the deflector from 4 to 6 inches below a smooth ceiling, a head must be able with 5 pounds nozzle pressure to wet the ceiling over an area of at least 3 to 4 feet in diameter and throw about 40 per cent of the water inside a floor area 10 feet square and with 50 pounds nozzle pressure not less than 75 per cent of the water must be thrown within the 10 foot square.

Although a sprinkler may have a rotary deflector and a spring under the valve seat to expedite the opening after the solder has fused it will not be approved unless the head can pass the above test independent of the help of these features.

Types. Of about 300 different types of sprinkler heads which have appeared, less than a dozen have been successful enough to survive and bear the approval of insurance companies.*

At the present time those sprinklers which have come up to the standards and are approved by the Underwriters are as follows: The

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*A very complete collection of pictures of old and new types of sprinkler heads is published by the Insurance Field, Louisville, Ky.

Crowder, Issue A; Garrett, Issue A; Grinnell Improved 1903; Hibbard, Issue A; International, Issue B; Manufacturers, Issue C; Neuracher, Improved 1902; Niagara-Hibbard, Issue B; Rockwood, Issue C.

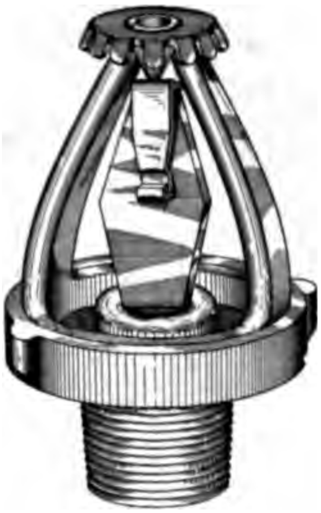

Fig. 90. Grinnell Sprinkler Head Closed

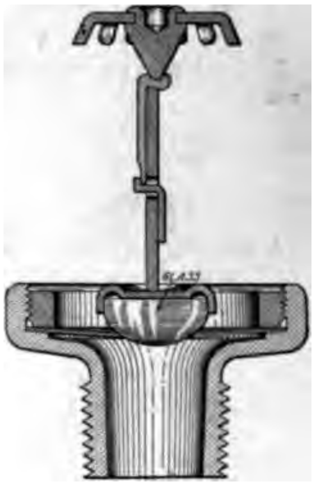

Fig. 91. Section of Grinnell Closed Head

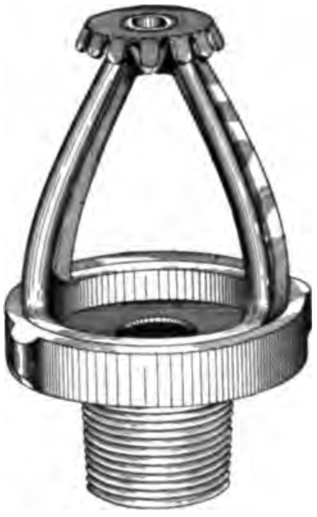

Fig. 92. Grinnell Sprinkler Head Open

Grinnell. The form of Grinnell head now in use is illustrated in Figs. 90, 91, and 92. The chief fault with the early Grinnell issues was that the valve disk was composed of a metal which either corroded or was so soft that under constant water pressure it became indented and stuck. The present issue of the Grinnell head has a glass valve disk; this is held against a flexible aluminum bronze valve seat which is sprung inward. This glass stopper is held in place by an arrangement of three metal pieces which are soldered together and braced between the deflector and the glass valve.

It is evident that the greater the water pressure the tighter the joint between the valve and the flexible valve seat. Furthermore when the head starts to open, the water pressure as well as the tension of the valve seat forces it to follow the glass disk outward, keeping the joint tight until the solder is entirely melted. In this way its being chilled and reset is prevented. The water that is discharged strikes against the pronged splash plate and is broken into a shower.

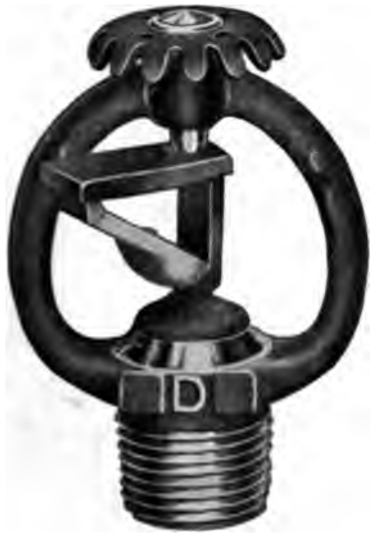

Fig. 93. Rockwood Sprinkler Head Closed Showing Fusible Metal Seal

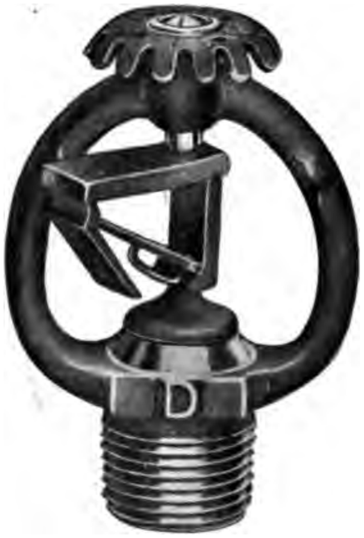

Fig. 94. Rockwood Sprinkler Head About to Spring Open

Rockwood. In the Rockwood sprinkler head, Figs. 93, 94, and 95, the valve disk is of metal and the arrangement of pieces holding the valve in place is such that the fusible part is held out in an exposed position.

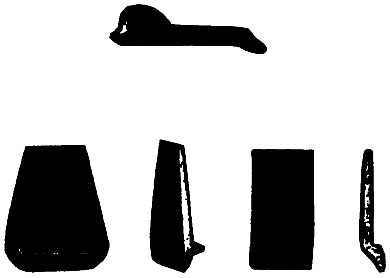

Fig. 95. Separate Parts of Rockwood Sprinkler Seal

Manufacturers. Figs. 96 and 97 illustrate the construction of the Manufacturers' head. The valve disk in this is porcelain and the valve seat at the point of contact is German silver, which prevents corrosion. Beneath the

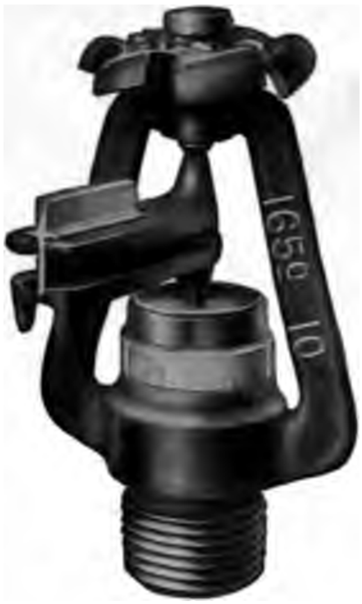

Fig. 96. Manufacturers' Sprinkler Head Closed

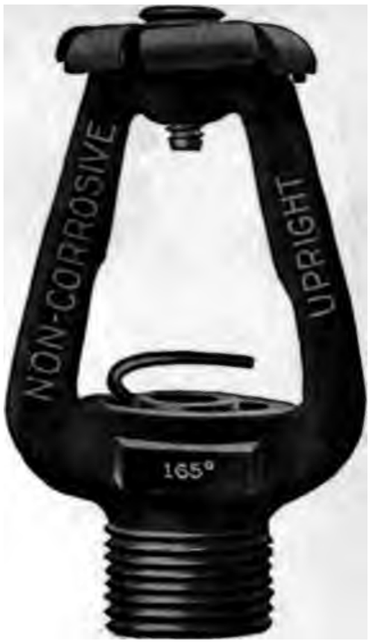

Fig. 97. Manufacturers' Sprinkler Head Open

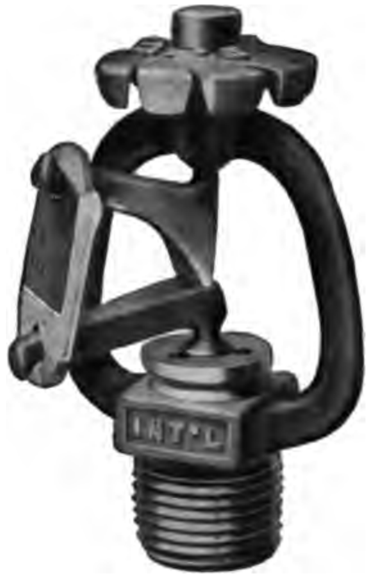

Fig. 98. International Sprinkler Head Closed

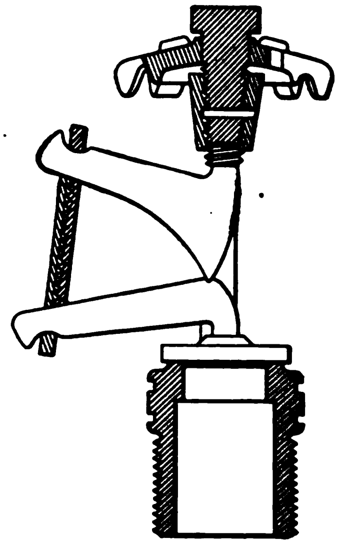

Fig. 99. Section of International Sprinkler Head

TABLE II

Number of Sprinklers to Given Size of Pipe

Size of Pipe (Inches)	Maximum Number of Sprinklers Allowed
¾	1
1	2
1¼	3
1½	5
2	10
2½	20
3	36
3½	55
4	80
5	140
6	200

valve is a coiled spring to unseat it quickly when the solder has melted, although without the spring the valve is readily unseated by means of the water itself.

International. Figs. 98 and 99 illustrate the International sprinkler in which the valve disk or valve cap is of bronze and is held in place by two levers whose ends are in turn secured by a fusible link.

INSTALLATION OF SPRINKLER SYSTEMS

Sprinkler Spacing. When in use these sprinkler heads are attached at intervals of from 6 to 12 feet to a system of overhead

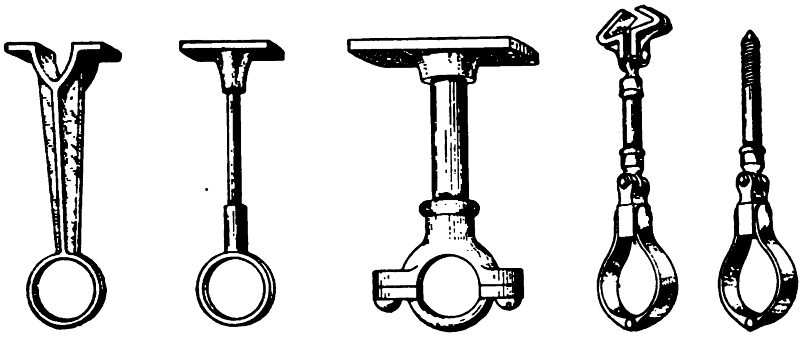

Fig. 100. Various Forms of Ceiling Hangers for Sprinkler Pipe

pipes running in parallel lines about 10 feet apart. The pipes which are constantly supplied with water under pressure are hung or suspended from the ceiling by wrought or cast iron hangers, Fig. 100. The sections of pipe between the sprinkler heads are connected at each sprinkler by a tee, Fig. 101, to which the sprinkler itself is attached. These ceiling sprinkler pipes slope at least ¼ inch in every 10 feet toward the feed pipe, which in turn slopes toward the riser that supplies it, in order that the entire system can be drained. Each ceiling pipe also gradually decreases in size according to the number of sprinklers which it has to feed, as shown by Fig. 102. Table II shows the size of the pipe necessary to supply to each sprinkler a proper amount of water under good pressure, when all the heads are open.

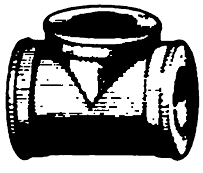

Fig. 101. Sprinkler Pipe Tee

Feed. There are various ways of arranging these overhead lines and their feeders and of connecting them to the main riser from which they draw their supply, as shown in Figs. 103 to 108 inclusive. Of these the *center central* and the *side central* are the best, the former being preferred if there are over 6 sprinklers on a branch line.

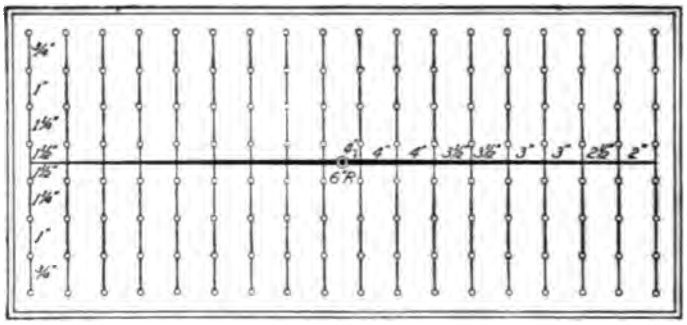

Fig. 102. Sprinkler Piping System Showing Reduced Sizes of Pipes According to Number of Sprinkler Heads

Preparation of Building for Installation. In order that the water from the sprinklers may reach every part of the building and stock, a clear space of at least 2 feet must be allowed for below the ceilings, which means that high shelves, decks, and high piles of stock must be removed. Furthermore, there must be no concealed spaces such as under ceilings or sheathing, in hollow sidings or in small cupboards, etc.

Since vertical drafts act to carry the heated air away from the sprinklers, all floor openings, etc., causing such drafts should be stopped by approved doors or traps; in case two floors must communicate with such approved stops, curtain boards or cornices extending at least 6 inches below the fusible part of the sprinklers must be fitted around the openings in order to bank up the heated air from a fire so that instead of its being carried away from the sprinklers it will accumulate and act upon them.

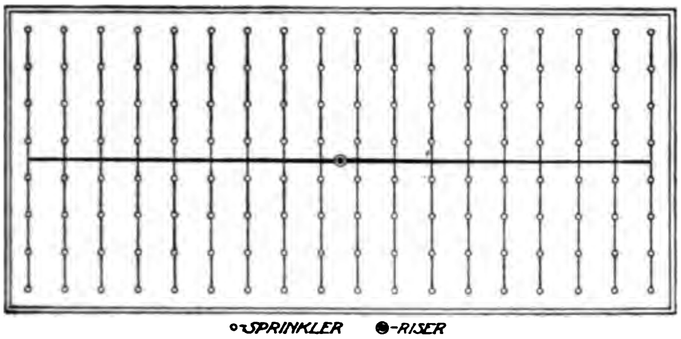

Fig. 103. Center Central System of Distribution of Sprinkler Feed Pipes

Extent of System. When a sprinkler system is installed insurance companies require that it should extend to every part of a building including basements and lofts; under stairs; inside elevator wells; in belt, cable, pipe, gear, and pulley boxes; inside small enclosures such as drying and heating boxes, dry room enclosures, chutes, conveyor trunks, and all cupboards and closets, unless they have tops

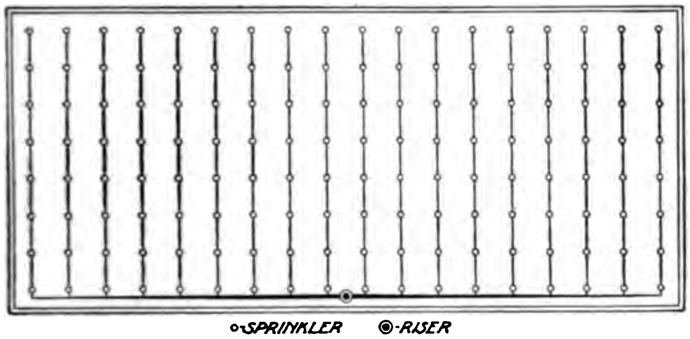

Fig. 104. Side Central System of Distribution of Sprinkler Feed Pipes

entirely open and are so located that the sprinklers can spray into them. No part of any building is to remain unprotected because it is wet or damp, or because it is of fireproof construction.

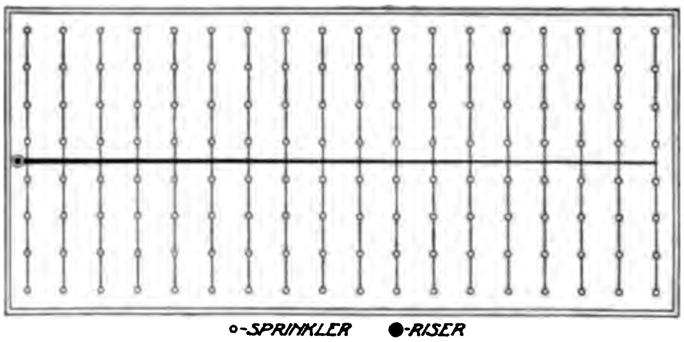

Fig. 105. Distribution System for Sprinkler Feed Pipes Similar to Fig. 104, but with Riser on the Short Side

If any unusual features exist, such as boxed machines, ventilators, etc., special instruction must be obtained from the Underwriters having jurisdiction, concerning the location of the sprinklers in these parts of the buildings.

Position and Distribution of Heads. The sprinkler heads themselves should be attached to the pipes in an upright position unless special permission is granted to have them pendant. The

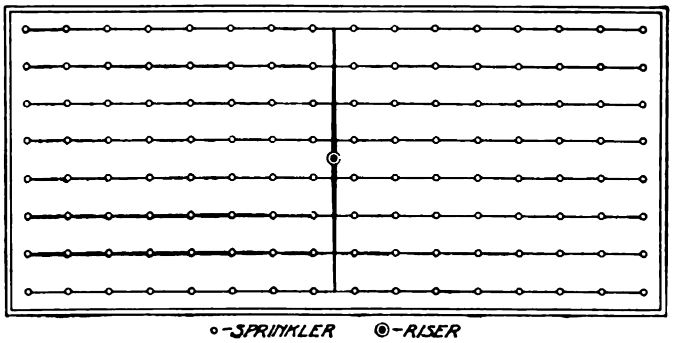

Fig. 106. Distribution System for Sprinkler Feed Pipes Similar to Fig. 103, but with Main Feed Across Center

deflectors of the sprinklers should be parallel to the ceiling, roof, or incline of the stairs, etc., except when installed in the peak of the roof where these should be horizontal. The pipe lines must be suspended from the ceiling at such a distance that the deflectors of the attached sprinklers shall not be less than 3 nor more than 10 inches below the ceiling.

Vertical shafts having inflammable sides, even though they are covered with plaster or metal, should be provided with a sprinkler for each 200 square feet of the surface. If possible these sprinklers should be installed at each floor, and always at each floor if the shaft is fitted with trap doors.

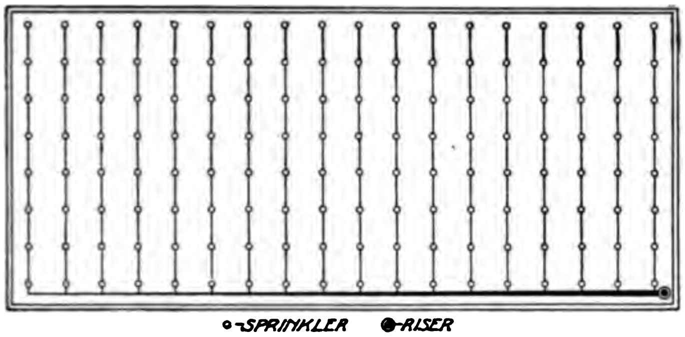

Fig. 107. Distribution System for Sprinkler Feed Pipe with Riser at One Corner and Branching from Longer Side Unapproved

In most buildings the floors are laid upon beams, joists, etc., which project below and form channels in the ceiling beneath. The width of these channels or "bays," as they are called, depends upon the construction of the building; upon the width of these spaces depends the arrangement of the sprinklers.

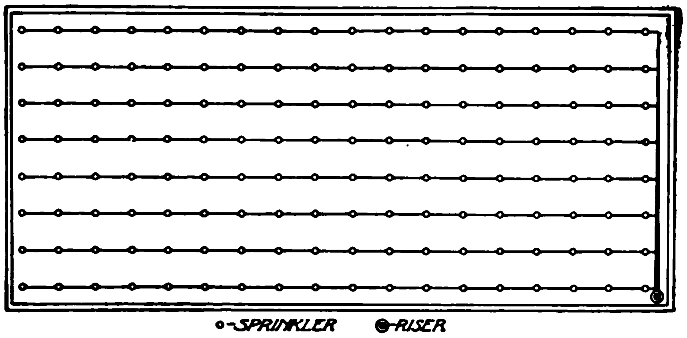

Fig. 108. Distribution System for Sprinkler Feed Pipe with Riser at the Corner and Branching from Short Side. Unapproved

Under a *mill ceiling*—that is, one constructed of heavy plank resting on timbers spaced from 6 to 12 feet apart—one line of sprinklers should be placed in the center of each bay, and the distance between the sprinklers on one line should not exceed the following:

8 feet in 12 foot bays
9 feet in 11 foot bays
10 feet in 10 foot bays
11 feet in 9 foot bays
12 feet in 6 to 8 foot bays

Under an *open finish joisted ceiling* the distance between sprinklers measured at right angles with the joists should not exceed 8 feet, and measured parallel to the joists should not exceed 10 feet.

Under a *smooth sheathed or plastered ceiling* where the supporting girders or timbers project, one line of sprinklers should be placed in the center of each bay thus formed if they are 12 feet or less in width. If they are from 12 to 23 feet wide there should be two lines of sprinklers, and in bays of greater width the lines of sprinklers should not be over 10 feet apart. In all these cases where the bays are more than 12 feet wide the sprinkler heads must be so spaced that each head is not required to cover more than 100 square feet of ceiling area.

Under a *pitched roof* which slopes more sharply than one foot in three, either one line of sprinklers may be located in the peak of the roof or else lines may be located not more than 2½ feet distant each way from the peak, and the sprinklers on either side should be located according to the rules given above for the various kinds of ceilings. The distance between these sprinklers should be measured on a line parallel with the roof. Whenever the roof comes down to the floor as in attics, etc., there must be a line of sprinklers not over 3½ feet from the place where the roof and floor meet.

Under *open finish joisted floors* and under *decks* and *roofs* the sprinkler heads should be staggered, that is, the heads on one line should be opposite points half way between the sprinklers on the next line. The end head on alternate lines should be not more than 2 feet from the wall or partition.

In any sprinkler equipment, no matter what the construction of the ceiling or the width of the bays, the distance of the outside sprinklers from the wall or partition should not exceed one-half the the distance between the sprinkler heads in that direction. Moreover, there should be sprinklers either side of a partition even though the partition be slatted. Cutting holes in a partition to allow the sprinklers on one side of it to spray onto the other side is not approved.

Risers. The methods of attaching the small sprinkler pipe lines to the main feeders have already been shown in Figs. 103 to 108, the illustrations also indicating the points where the risers join the overhead feeders. There should be one or more such risers for each building or section of a building that is divided by fire walls. Stair, dumb waiter, and elevator towers are sometimes piped on independent risers.

Except special permission is granted to do otherwise these risers must be fed from the bottom. When the water supply comes from the city mains, pump, or the fire department, such a connection would be the most direct. When, however, the supply is from roof tanks the water must be piped from the top of the building to the foot of the riser, such pipes being commonly known as "dead risers." Each riser must be large enough to supply all the sprinklers on one floor as specified in the table of pipe sizes. The risers in towers which are not cut off by approved fire stops must be large enough to supply the entire number of sprinklers in the tower. The connection between the water supply and the sprinkler riser must be as large as or larger than the riser itself.

SPRINKLER WATER SUPPLY

For a standard equipment two independent water supplies are absolutely necessary, of which one must be automatic and the other must be able to furnish heavy pressure. For one of these the public water works system is usually used, but if this pressure is too low, the water supply may be secured from some type of fire pump, from a gravity or pressure tank, or from a private reservoir or standpipe, although, on account of the expense, the latter is seldom used.

Besides having two supplies from any two of the above sources it is best, if there is a public fire department, to provide a hose inlet pipe, or steamer connection to the sprinkler system, so that the fire engine can pump into it. These connections must be of brass with a thread to fit the couplings of the local fire department. Each connection must be marked in raised letters one inch high or larger: "AUTOMATIC SPRINKLERS."

Public Mains. If one water supply for a sprinkler system is taken from the public water works system, the pressure must be sufficient to furnish water to the highest line of sprinklers with 25 pounds static pressure day and night and 10 pounds flowing pressure when water is being discharged from the maximum number of sprinklers apt to be opened by a fire. If this water supply is used the street mains must be of ample size, never less than 6 inches, and they should preferably be fed from both ends. No meter or pressure-regulating device should be used on the pipe without the special permission of the proper authorities.

Fire Pumps. When pumps are used to furnish one water supply to the sprinklers (1) the pump and the pump house should conform to the National Standard requirements as described in Fire Insurance Inspection Part IV; (2) the pump should draw from some source sufficient to enable it to deliver its full rated capacity; (3) for at least sixty minutes the pump, in discharging during this time, should not reduce the level of the water so as to make the suction pipe longer than 15 feet.

If the pump's supply comes from a river, lake, or other body of water likely to contain refuse or dirt, a well screened intake-well should be provided to prevent accumulations of dirt entering the suction pipe. In all cases the suction pipe should be as short and direct as possible, thoroughly protected against frost and fitted with a strainer protected so that it can not become clogged. If unusual conditions make necessary a suction pipe longer than 15 feet it should be fitted with a foot valve.

Cistern as Pump Supply. A reliable natural source is not always available and the pump must sometimes draw from a cistern provided with some dependable means of filling. If it is filled from the city mains, the pipes to it should not be less than 2 inches in diameter and they should be fitted with a ball and cock valve to keep the cistern automatically filled to a certain level. If possible the cistern should be built and located so as to supply the pump under head for at least ten minutes. In the bottom of the cistern there should be a pit or *sump* into which the suction pipe should extend so that all the water may be drawn out for use.

Steam Supply. When a steam pump is used all boilers, pipes, and valves involved in supplying steam to the pump must be most carefully arranged and protected to insure a reliable steam supply at all times and under all conditions. The boilers should be furnished with water from a source not apt to be crippled in case of fire and they should be of such capacity (never under 40 b.h.p. for each 250 gallon pump capacity) that they can furnish steam to run the pump at its full capacity.

The connections between the boiler and pump should be entirely independent of any other pipe lines; in fact it is better that such connections leave the boiler header at the end opposite to that at which the main factory engines are fed. This steam feed pipe should be free from traps or pockets and located so that it would not be injured in case of fire. At the pump the pipe should be fitted both with a drip and a steam trap so located that a closed throttle will not interfere with their working.

When more than one boiler contributes to steam supply, the pipes and valve should be so arranged that at any time the steam from any one boiler may be cut off without interrupting the supply from the others. Likewise if there is more than one pump each should be arranged to be cut out without interfering with the others. Each pump should also have an independent exhaust pipe equipped at its lowest point with an open drain.

If an automatic regulator is used on the steam connection to the pump it should be placed on a by-pass with a shut-off valve either side of it.

The pipes carrying steam to the other parts of the building should be fitted with valves in the boiler room so that in case of fire this supply may be cut off and the steam devoted to the use of the fire pumps.

Recording Gauge. If the pump is the primary supply a recording gauge may be used to record either the steam pressure at the pump or the water pressure at the discharge pipe. This gauge should be placed in a box or cabinet on the wall, and the unused dials, the ink, and the used dials showing the record should be kept with it.

Gravity Tank. The gravity tank is probably the most frequently used source of water supply for sprinklers, especially in cities where the pressure in the public service mains is low. A gravity tank, Fig. 109, is a tank of wood, steel, or concrete elevated on a roof or trestle so as to give a good gravity head at the point where the water is to be supplied. These tanks even under the best conditions often collapse, for they are exposed to all the weakening influences enumerated in the discussion of standpipes, Inspection Part IV, and furthermore the hoops are likely to rust from the inside out. In consideration of the loss and danger to life and property from the failure of a tank, the greatest care should be taken that the design, material, and workmanship of these structures is of the best.

If a trestle is to be used to support the tank at the desired elevation this trestle must be securely bolted to a solid foundation of concrete which should extend well below the frost line to a proper bearing surface. Whether the tank is on a trestle or on a building the supporting structure should be of steel, reinforced concrete, or solid masonry, but never of wood except by the special permission of the proper underwriters. These tank supports should be designed to carry the load with a factor of safety of at least four.

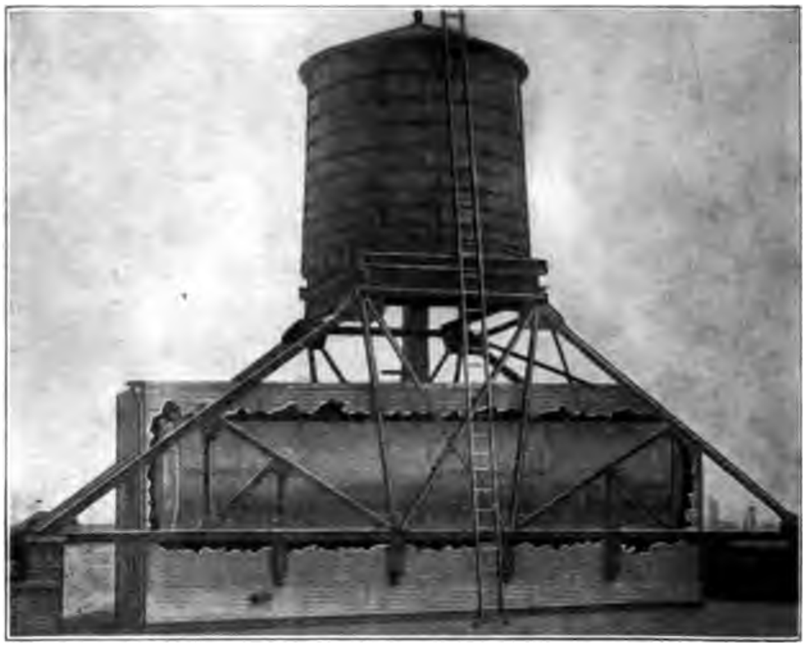

Fig. 109. Gravity Tank Properly Supported by Trussed Framework and Pressure Tank Enclosed in Brick Housing

Although the local building authorities and building laws must determine the design and construction of a gravity tank, yet wherever such a tank is built, insurance companies impose the following requirements:

> In no case should the capacity of the tank be less than 5,000 gallons. If it is on a detached trestle as the safety of life and property make it most desirable, there should be a platform entirely around it. If located on the roof it is best placed on a solid masonry foundation built over the stair or elevator tower. Often, however, to secure sufficient elevation, it is necessary to support the tank on a trestle erected on the roof of a building. If any part of this structure enters the building it must be most carefully insulated and especially safeguarded against corrosion where the steel supports pass through the roof. Both the tank and its support, if composed either of steel or wood, must be kept thoroughly painted at all times. All parts that are of steel should be riveted together and no bolts used except the foundation bolts already mentioned.
>
> Wood tanks should be made of a good quality thoroughly air dried cedar, cypress, or white pine. The staves and the bottom of tanks not over 16 feet in diameter and 16 feet deep should be of 2½-inch stock dressed to not less than 2¼ inches. Larger tanks require 3-inch stock reduced in dressing to not less than 2¾ inches. The tank must taper from 1½ to 1 inch per foot.
>
> Flat hoops must never be used but instead round hoops at least ¾ inch in diameter, either of a good quality of wrought iron, or of mild steel without welds, and they should be thoroughly painted both before and after they are put on. The space between two hoops should never exceed 21 inches. They should be of such size and so spaced that the stress on a hoop measured at the base of the thread should not be more than 12,500 pounds to the square inch.
>
> The water from these tanks must be devoted exclusively to the automatic sprinklers unless the underwriters having jurisdiction grant permission to make the tank larger than demanded by the sprinkler needs on condition that it be so piped that only the excess can be drawn off for other purposes.

Feed. Each tank should be fitted with at least 1½-inch filling pipe which should discharge into the tank above the top of the water.

Discharge. The discharge pipe should enter the bottom of the tank and project 4 inches up inside, thus leaving a space for sediment to settle. If over 30 feet of this discharge pipe is exposed above the ground or roof it must be fitted with an expansion joint of some approved kind to allow for the expansion and contraction due to changes of temperature.

If this pipe feeds but one riser, its diameter should not be less than that of the riser. If it feeds several its diameter should be at least as large as that of the largest riser. If the "dead riser" is more than 100 feet long its diameter should never be less than 6 inches.

Drain. Provision should be made to drain each tank into some inside sink without interfering with other tanks or with the sprinkler system.

Overflow. There should be as near the top of the tank as possible an overflow pipe, at least 2 inches in diameter, arranged to discharge where it will be noticeable and yet where it will not cause accumulations of ice on the structure. The tank must be fitted with a *telltale* or water-level indicating device.

Protection. Both tank and pipes must be carefully protected against freezing. In the case of the tank this may be accomplished by putting in the bottom a brass or galvanized iron steam coil with a return pipe to the boiler, or the tank may be fitted with a steam pipe which discharges under the water near the top, and which is fitted with a check valve and a perforated fitting to prevent siphoning.

The pipe may be kept at a safe temperature by being protected by a double, triple, or quadruple boxing according to the climate, or instead a steam pipe may run close to it and keep it above the freezing point.

Ladders, Covers, Etc. To prevent evaporation and accumulations of dust on the water, each tank should be provided with a double cover with an air space between; the upper cover should preferably be conical. In each case there should be a trap door to permit access for inspecting and repairing, and for this same reason there should be a substantial iron ladder extending above and permanently attached to each tank.

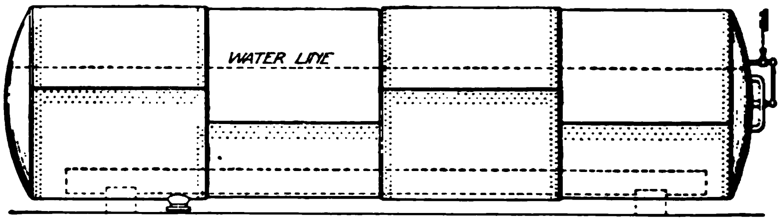

Fig. 110. Detail Drawing of Pressure Tank with Fittings

Pressure Tank. A pressure tank, shown below the gravity tank in Fig. 109 and in detail in Fig. 110, is a cylindrical steel tank designed to be two-thirds filled with water and the remaining third with compressed air so that its supply of water to the sprinklers is under high pressure. Since one supply under high pressure is required this means of obtaining it is often used, automatic pumps not being reliable and the public water works seldom being able to supply sufficiently high pressure.

Such a tank was first used in Boston in 1883 and since then because of its many advantages its use has rapidly increased. It does not need the heavy construction and the great elevation necessary for a gravity tank. It can often be located within a building on floors already constructed, and in a position where it is not in danger of being frozen. As it is air tight the loss by evaporation and the consequent necessity of frequent filling is eliminated. The air pressure seldom has to be pumped up more than once a month, thus making the expense of maintenance as well as the first cost but small.

The greatest disadvantage of the pressure tank is its limited capacity, and yet it is designed to furnish a reasonable number of sprinklers for as long a time as is usually required to extinguish a fire in its incipiency. As the water escapes, the pressure is necessarily reduced, yet very gradually, and according to requirements sufficient air pressure is maintained so that even when the water is exhausted the pressure at the highest line of sprinklers is not reduced below 15 pounds.

The National Board of Fire Underwriters requires that a pressure tank should not be located below the first floor; that it should have a total capacity of at least 4,500 gallons which must be devoted exclusively to the use of the sprinklers or the hand hose; that the tank should be constructed of an even quality fire box or flange steel having a tensile strength of not less than 55,000 nor more than 60,000 pounds.

Construction Data. The *thickness of the plates* to be used should be determined by the following formula:

$$T=\frac{6\times P\times r}{.75\times S}$$

in which T is the thickness of plate in inches, P is the working pressure in pounds per square inch, r is the internal radius of shell, S is the tensile strength of plates in pounds per square inch, 6 is the factor of safety, and .75 is the value of riveted joints.

If the diameter of the tank is not over 84 inches the *heads* should be ⅛ inch thicker than the shell and at least ¼ inch thicker than the shell for all diameters greater than 84 inches. The *longitudinal seams* should be triple riveted and placed below the water line.

The *girth seams* may be single riveted unless the tank diameter is more than 84 inches, when they should be double riveted. All seams should also be thoroughly caulked both inside and outside.

Manhole. At some point below the water line there must be a manhole large enough to permit access for inspecting, cleaning, etc.

Plate. Attached to the proper position on the tank there must be a metal plate bearing a metallic horizontal line indicating the two-thirds water level of the tank. The height of this level from the bottom of the tank may be found by multiplying the radius of the tank in inches by 1.265. On this same plate must be painted the minimum air pressure allowed.

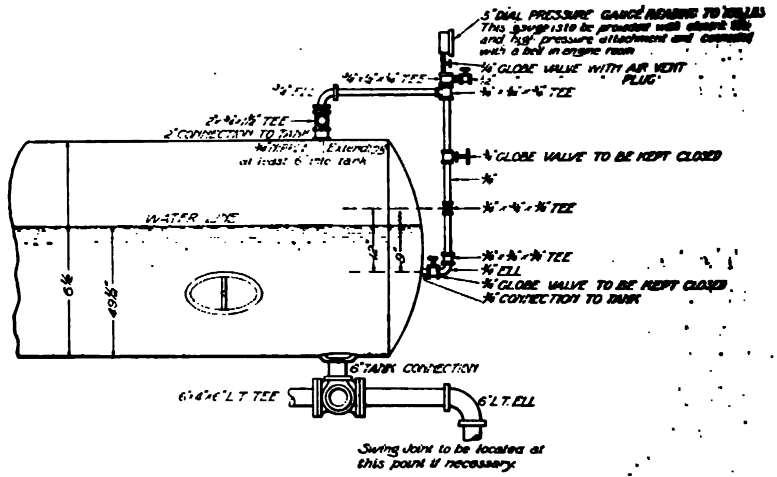
5" DIAL PRESSURE GAUGE READING TO
This gauge is to be provided with electric
and high pressure attachment and connected
with a bell in engine room
GLOBE VALVE WITH AIR VENT PLUG
TEE
TEE
ELL
2" × 1/2" TEE
2" CONNECTION TO TANK
Extending at least 6" into tank
GLOBE VALVE TO BE KEPT CLOSED
TEE
WATER LINE
TEE
ELL
GLOBE VALVE TO BE KEPT CLOSED
CONNECTION TO TANK
49½"
42
6"TANK CONNECTION
6"L T TEE
6" L.T. ELL
Swing Joint to be located at this point if necessary

Fig. 111. Section of Pressure Tank Showing Connections for Both Air- and Water-Feed Pipes

Water Feed Pipes. The feed pipe to the tank must be at least 1½ inches in diameter; risers or other sprinkler pipes should never be used for this purpose. The best method of feeding the tank is by a pump, for then the proper water level may be restored without opening the tank and reducing the air pressure.

Air Feed Pipes. The pipes supplying compressed air must not be smaller than 1 inch in diameter at any point between the air pumps and the tank. They must enter the tank above the water level and at such a point that the gauges may be attached as shown in Fig. 110.

Both air and water feed pipes must be fitted with check and globe valves, as seen in Figs. 111 and 112, which shows the connec-

SAVED FROM CONFLAGRATION BY AUTOMATIC SPRINKLERS
Windows Completely Burned Away, But Combustible Material Saved
Courtesy General Fire Extinguisher Company, Providence, Rhode Island

VERY COMBUSTIBLE BUT NOT MUCH HURT
Sounding-Board Rack in Piano Factory Slightly Damaged. Saved by Automatic Sprinkler
Courtesy General Fire Extinguisher Company, Providence, Rhode Island

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TILDEN FOUNDATIONS

tion to a pressure tank as recommended by the New York Fire Insurance Exchange.

The air pressure may be produced by either a steam or an electrically driven air compressor provided it has sufficient capacity to increase the air pressure at an average rate of at least 1 pound in two minutes.

Discharge. A discharge pipe should be fitted into the bottom of the tank. At some point between the tank and the roof, this pipe should have a side outlet fitted with a gate valve for draining. If there is more than one tank, each should drain independently of the others and of the sprinkler system. The method first employed of bringing a drain pipe from the tank to some lower floor, or of extending it to the bottom of the building on the outside where it was accessible from the ground, is not approved.

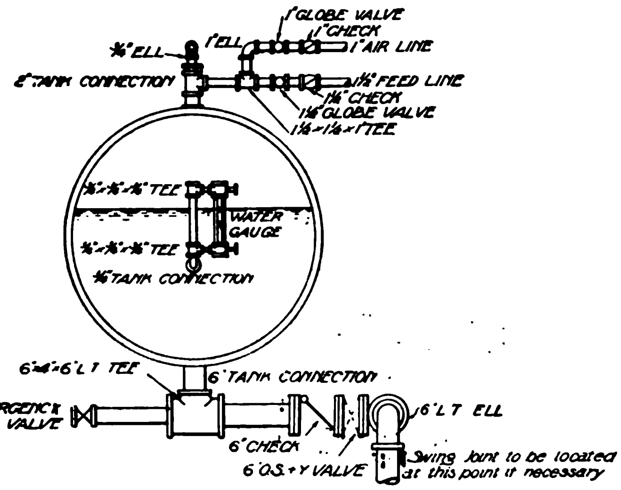

Fig. 112. End of Section of Pressure Tank Showing Gauge and Pipe Connections

Test. These tanks should remain tight under a hydrostatic test pressure at least 25 per cent greater than the normal working pressure required. Following this test the water should be drawn down to the two-thirds line and the tank tested under the working air pressure required. To be satisfactory the tank should remain in this condition with all valves closed for 24 hours without showing more than ½ pound loss of air pressure.

Pressure. According to the standard requirements the air pressure maintained in these tanks must be sufficient to supply 15 pounds air pressure at the highest line of sprinklers when all the water has been discharged. This requirement necessitates that in a tank which is on a level with the highest line of sprinklers, 75 pounds air pressure must be maintained when the tank is two-thirds full of water, this 75 pounds being the minimum pressure allowed whatever the elevation of the tank. If the tank is set below the highest line of sprinklers, then a pressure in excess of 75 pounds must be maintained, this excess being equal to 3 times the pressure due to the height above the tank of the water column up to the sprinklers.

To illustrate this and show its necessity, consider the following conditions: When the tank is two-thirds full of water and before the air pressure has been pumped up, the pressure on each square inch of the surface of the water is that of the atmosphere only, viz, about fifteen pounds. The compressed air gauge stands at zero.

Now if there is a line of sprinklers 30 feet above the tank the 30 foot column of water between these and the tank produces a back pressure into the tank of $\frac{30}{34}$ of 15 pounds or about 13 pounds. According to the requirement given, therefore, the air pressure must be pumped up until the gauge reads

> 75 lbs. (min. air pressure)+39 (3 times head due to highest line of sprinklers)=114 lbs. gauge pressure

Adding to this the 15 pounds pressure due to the atmosphere we obtain 129 pounds actual pressure in the tank.

If all the water in the tank is discharged then the volume of compressed air which at first was confined to one-third the capacity of the tank is increased three times and fills the whole tank. In increasing its volume three times the pressure is inversely decreased or becomes one-third of what it originally was—in this case $\frac{1}{3}$ (129) =43 actual pressure, or 43−15=28 lbs. gauge pressure. Of this 28 lbs. 13 is required to offset the pressure due to the elevation of the sprinklers, which leaves a working pressure of 15 pounds at the highest sprinklers.

Protection. If the tank is located outside the building it must be properly protected from frost, and, therefore, it should be enclosed

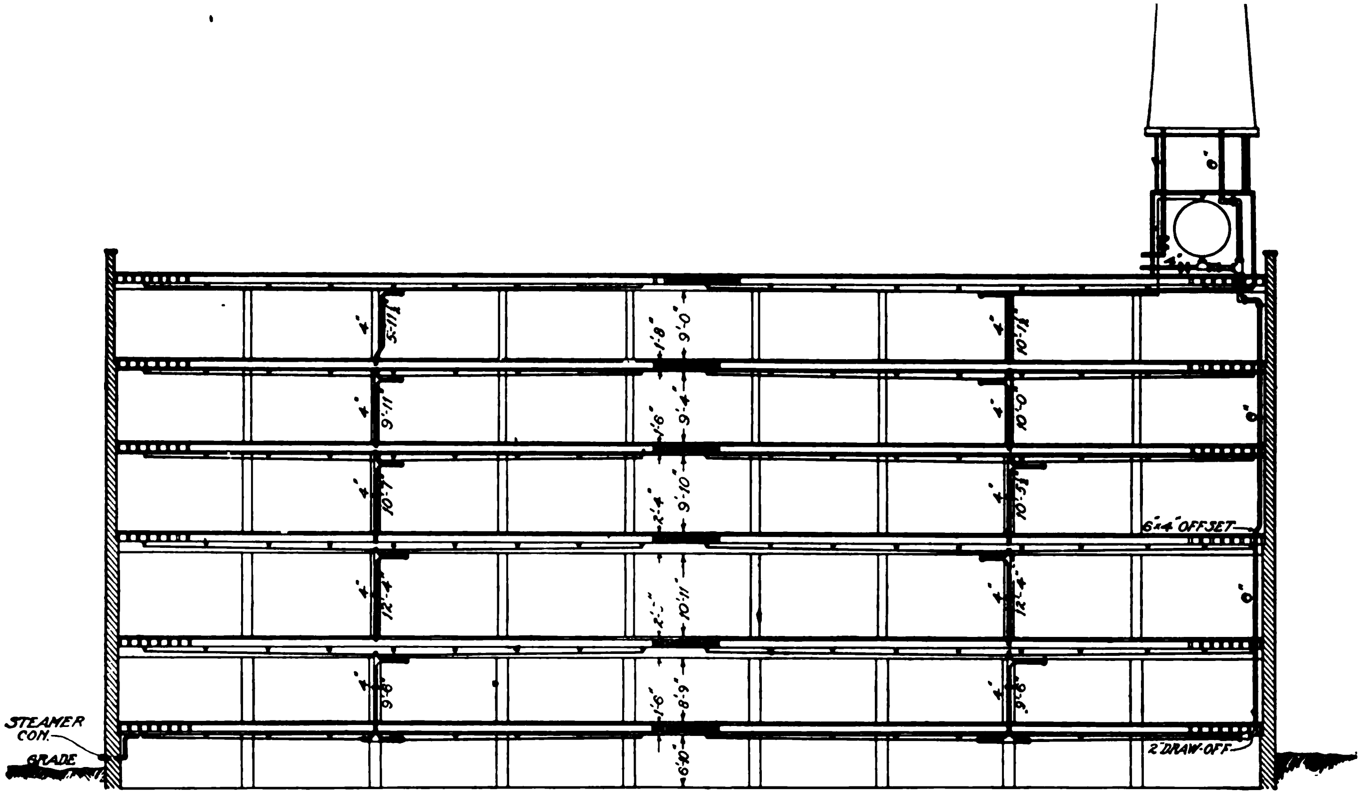

Fig. 113. Elevation of Factory Showing Floor Sections and Location of Gravity and Pressure Tanks and Piping System

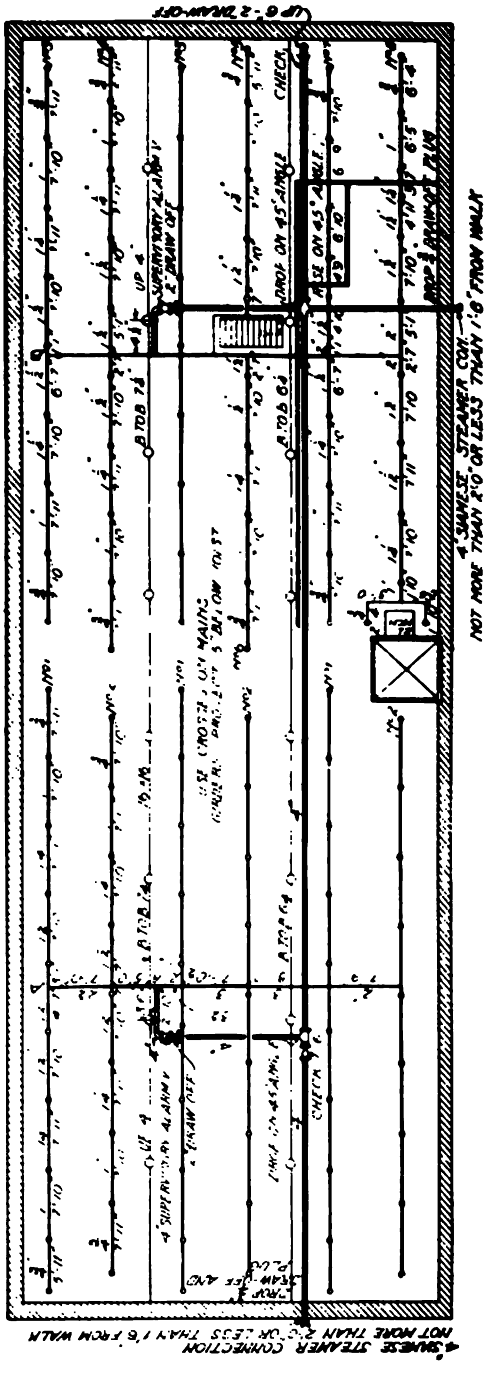

Fig 114. Basement Plan of Factory with Typical Sprinkler Installation Showing Location of Sprinklers and Pipes

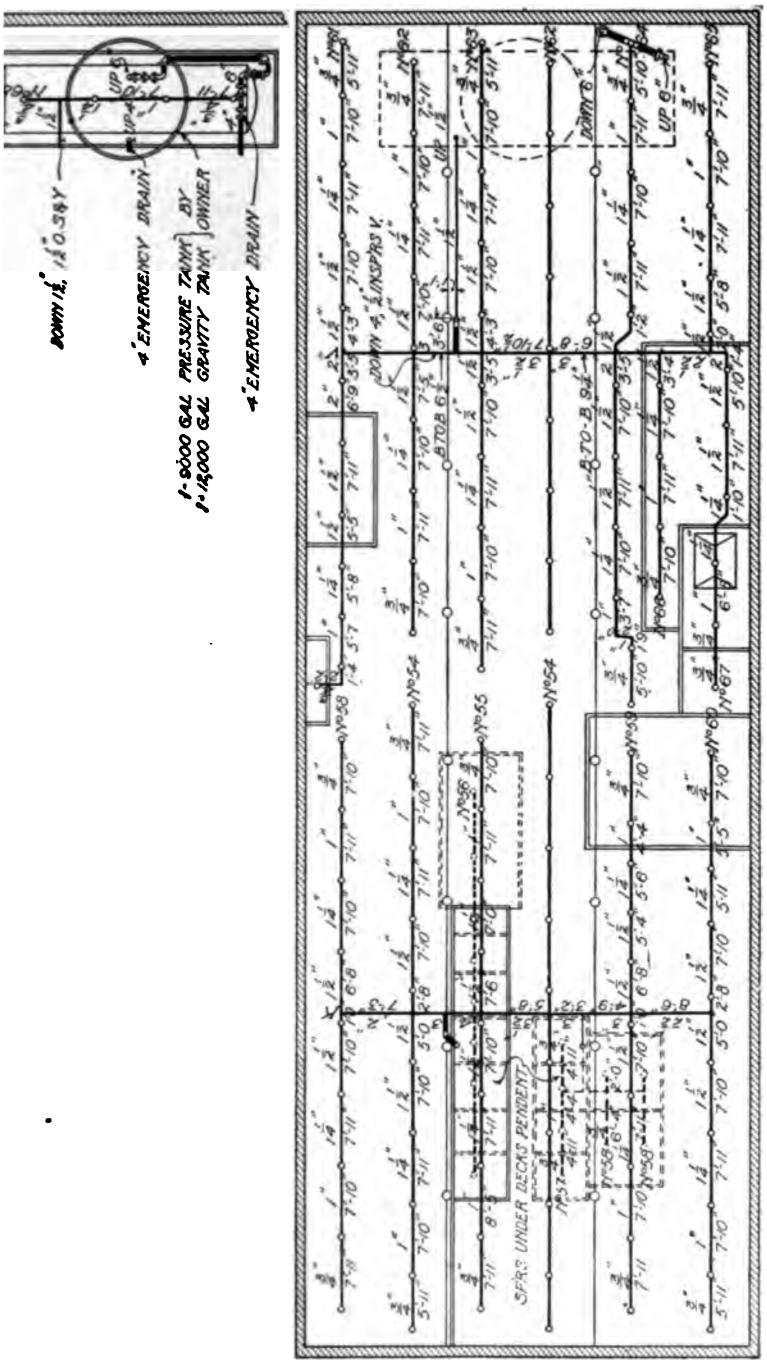

Fig. 115. First Floor Plan of Factory with Typical Sprinkler Installation Showing Location and Spacing of Sprinklers and Pipes

in a substantial house large enough to provide free access to all sides of the tank. Opposite the gauges at the end of the tank there should be a window, with a space between the window and the tank of at least three feet.

Supports. The tank supports must be designed to safely carry the load, using at least 4 as a factor of safety. The local building laws and authorities must govern in other respects the construction of the tank, tank supports, and house.

Gauges. If the tank is horizontal, gauges must be attached to its end; if vertical, to its side.

The water gauge shown in the diagram must be attached so that the center of the gauge glass will be directly in line with the mark indicating the two-third water level. As will be noticed in Fig. 111, the valves to the water gauge are to be kept closed usually, and opened only when a reading of the water level is desired. Were they kept open, the breaking or the leakage of the glass would allow the pressure to escape. The air gauge, however, is kept open. Globe valves, as illustrated, are used about a pressure tank because they seat more securely and do not leak as other types of stop valves are apt to do.

Typical Installation. A typical installation of a sprinkler system with gravity tank, pressure tank, and pipe connections is shown in Figs. 113, 114, and 115, Fig. 113 showing the elevation, Fig. 114 the basement plan, and Fig. 115 the first floor plan.

WET VALVES

In any sprinkler system numerous valves are necessary to control the water supply, to direct the flow of the water, to cut off any particular supply, to drain the system or any part of it, to send in an alarm, and for various other purposes.

Gate and Check Valves. The National Board of Fire Underwriters requires that all gate valves, etc., should be of an approved outside screw and yoke, or of an approved indicator pattern.

Whatever their design, all such valves in the supply pipes are to be kept open, and in the drain pipes closed, and every valve, according to its use, secured open or closed by a padlock, a riveted leather strap, or by seals if a reliable system is installed whereby immediate notice of broken seals will be given. The check valves must be of an approved straightway pattern installed in a horizontal pipe, unless suitably designed for a vertical position.

When these valves are installed underground they must be located in a pit which is accessible through a manhole. This pit must be tight enough to keep out water from the surface and from the ground, and it should have a deck forming a double air space to prevent freezing.

Each separate water supply to a sprinkler system must be fitted with both gate and check valves. The gate valve is necessary to shut off any supply for repairs and it should be located close to the supply, as near the tank or in the pipe between the riser and the water supply.

When water from two or more sources, and consequently under two or more different pressures, is being fed to a sprinkler system, the check valves are necessary to prevent whichever supply is under the heaviest head from forcing the water back to the source of the other supplies, as for instance when both a gravity and a pressure tank are connected with the same dead riser. If the check valve were not present, the high pressure from the pressure tank would force the water from this tank not only into the sprinkler system, but also up into the gravity tank against its smaller pressure. These valves should be located near the foot of the riser when the supplies enter at the bottom, but they must be placed at some higher point if two supplies enter the same "dead riser" at some higher level.

These regulations for valve positions may often be fulfilled in such a way that the gate valve and the check valve on the same supply may be located near each other. In such a case the check valve should preferably be located nearer the water supply than the gate valve, so that it may be possible to close the gate valve in order to examine or repair the check valve without interfering with other water supplies or with the sprinkler system.

One supply may be from a pump discharging into a yard main which is also fed by another supply. If this pump is not in a fireproof house, or for any other reason is apt to be incapacitated or injured during a fire, its discharge pipe should be fitted with a check valve or an approved indicator-post gate valve located underground at a safe distance from the building. Likewise if a tank discharges into a yard main fed by some other supply, its discharge pipe should be similarly fitted with valves. The reason for this is evident, viz, that the crippling of one supply may not disturb another. Whenever sprinklers are fed from a yard main the connecting pipe should be fitted with an approved outside indicator-post gate valve. Fig. 116 shows various common systems of grouping valves.

Steamer Connection. When a steamer connection is provided, it should be fitted with a straightway check valve or, if it has a Siamese connection, there should be a check valve in the Y. There should be no gate valves in this connection, however, although if the sprinkler system has but one riser, there should be a gate valve in this riser at some point above its connection to different water supplies, and another one below the connection between the riser and the steamer supply. By closing this valve, all supplies except that from the steamer may be cut off. If there is more than one riser, however, the steamer connection must be made on the supply side of this gate valve so that if one riser is shut off, the supply will feed the sprinklers on the other side.

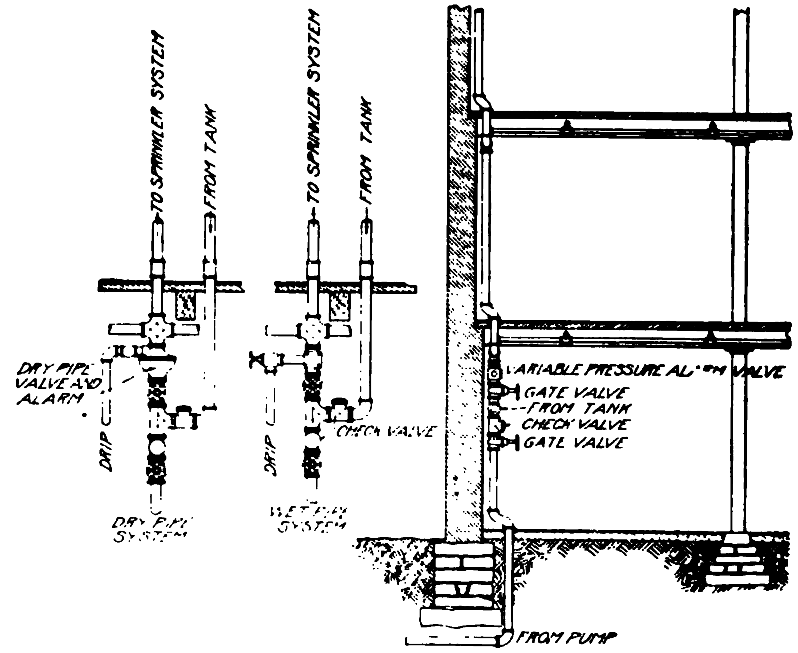

Fig. 116. Section Showing Common Methods of Grouping Valves for Dry Pipe and Wet Pipe Sprinkler Systems

Drainage. Mention has already been made of the provisions required for draining the tanks and also of the fact that all the pipes slope enough toward the risers to drain back into them. Running parallel to each riser for the entire length should be a drain pipe connected at the base with the sewer. At the foot of each riser, between it and the drain pipe, there should be a connection fitted with a gate valve. By opening this gate valve it is evident that the whole system dependent upon that riser can be drained into the sewer. In order to drain each floor separately, there should be a gate valve in each overhead feeder after it leaves the riser. Beyond this gate valve the feeder and the drain pipe should be connected by a pipe fitted with a gate valve, Fig. 117. By closing the first gate valve and opening the second, the pipe on one floor may be drained.

Test Pipe. At the top of each riser there should be a ¾-inch pipe with valve. In the best equipments this pipe is connected with the drain by a glass tube. By opening this valve and observing whether water flows through the glass tube into the drain pipe, it can be determined whether there is water in the system, *i. e.*, that all the proper valves are open and that there is no obstruction in the pipes. This test pipe is chiefly for inspectors' use.

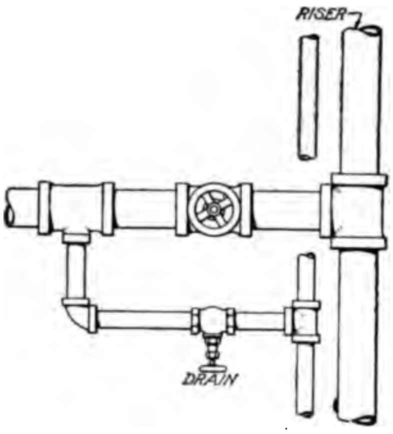

Fig. 117. Diagram Showing Method of Placing Drain Pipe in Sprinkler Piping System

Alarm Valve. At the foot of each riser there should be an alarm valve so arranged that an alarm will be sent in when the opening of a sprinkler causes a flow of water through the riser and through this valve.

The simplest form of such an alarm valve is a check valve placed in the riser, Fig. 118. When the sprinkler system receives its supply from either a pressure tank or a gravity tank, the static pressure throughout the entire system is constant and, therefore, would be the same on either side of this alarm check valve, which condition would keep the valve closed. In case a sprinkler head opens, the pressure on the system side of the check valve is immediately relieved, and the continued pressure on the supply side would open the valve, the clapper of which, when it is swung back, makes a contact which closes an electric circuit, the wires of which run to an annunciator that gives the alarm and indicates which section of the system is operating.

When a system is supplied from the public mains such a valve can not be used, as the pressure in the public system fluctuates during the day and night and such changes would frequently open the valve and give false alarms. For example, the pressure in the city mains and in the sprinkler system in the evening might be 30 pounds; during the night when less water is being drawn throughout the city, the pressure in the mains might rise perhaps to 60 pounds. This rising pressure on the supply side of the valve would open it until enough water had passed through to again equalize the pressure. Although the flow would be small, the valve just described would, in opening, send in an alarm. To prevent false alarms from just such causes, the variable pressure alarm valves have been devised, which operate only when there is a continued rush of water through the riser.

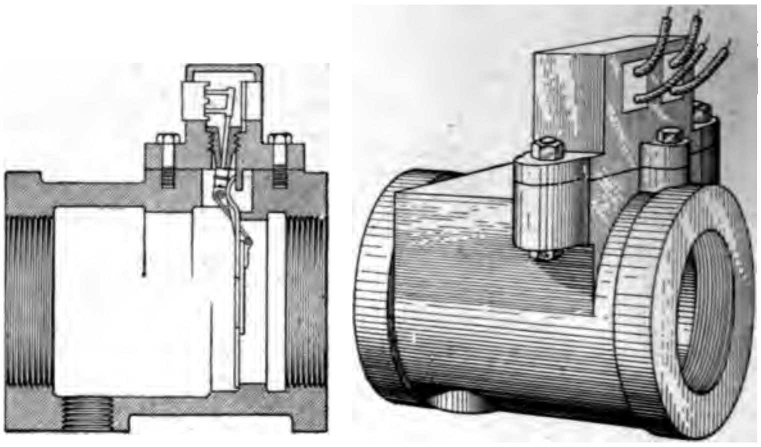

Fig. 118. Alarm Check Valve for Sprinkler System

At the present time, no alarm valve sufficiently reliable to be approved as standard by the National Board of Fire Underwriters has been devised, although reductions in rates are allowed for some types, among which are the following:

(1) Evans Variable Pressure, 1902 Model, manufactured by the International Sprinkler Company
(2) Grinnell English Pattern Variable Pressure (swing check or straightway type)
(3) Rockwood Variable Pressure
(4) Venturi

In some cases a rush of water through a variable pressure alarm valve gives the alarm by acting upon an electric circuit in a manner similar to that described for a constant pressure alarm valve. In other cases it also gives a mechanical alarm, that is, a part of the water rushing through the valve is conducted through a by-pass and falls over a wheel or acts upon a water motor which rings a powerful gong on the outside of the building.

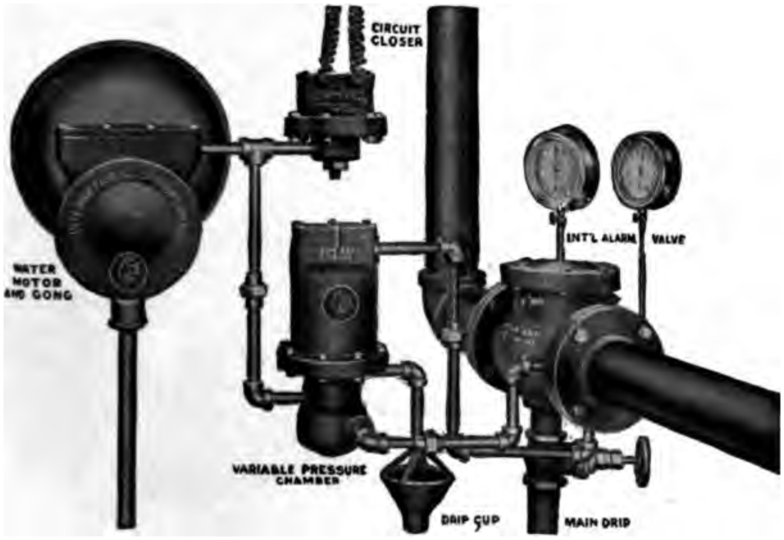

Fig. 119. Alarm Check Valve for Sprinkler System with Alarm Mechanism Complete
International Sprinkler Company, Philadelphia, Pennsylvania

International. The alarm check valve manufactured by the International Sprinkler Company is illustrated in Figs. 119 and 120. As shown in Fig. 120 the diaphragm and the lower seat plunger, *B 10* and *8*, are in their normal position. When in this position they

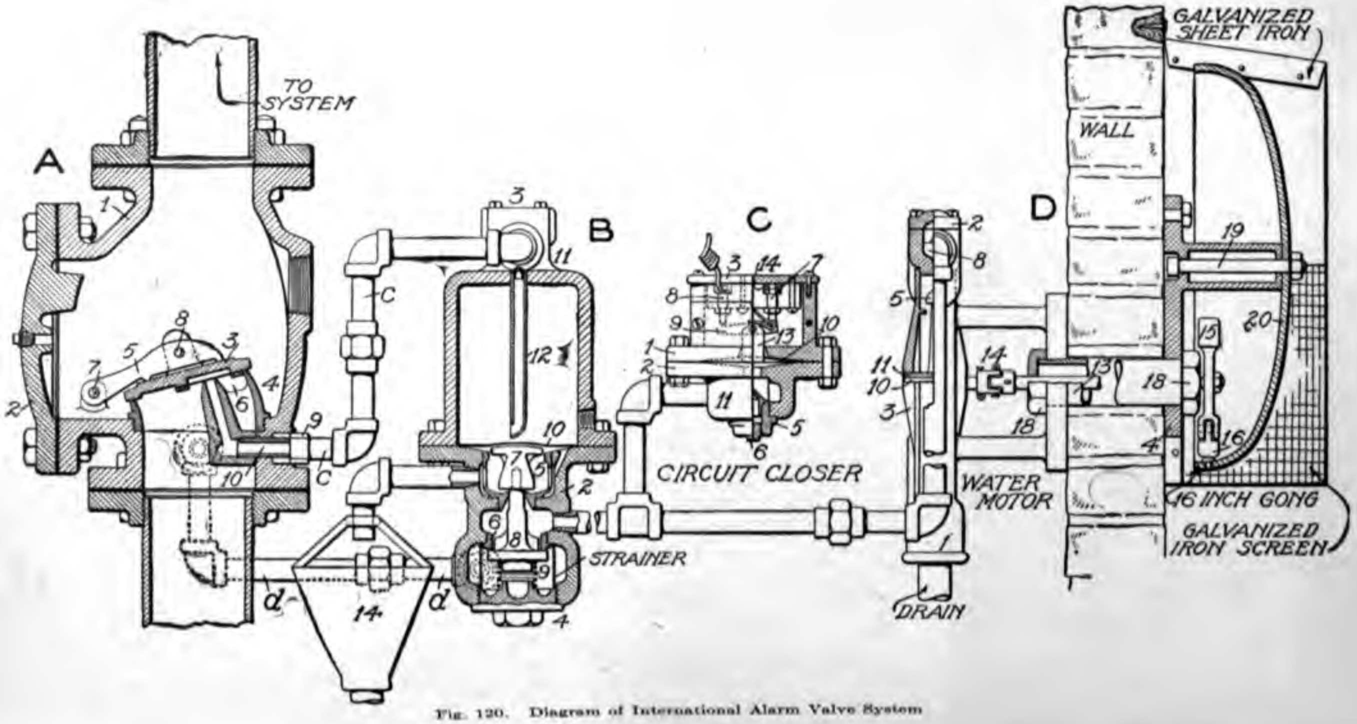

Fig. 120. Diagram of International Alarm Valve System

are so constructed that they close the parts from the pipe to the lower chamber of *B* and open the port from this chamber to the drip cup, *B 14*. Diaphragm *10* is flexible and any rush of water into the upper chamber of *B* drives it and the lower seat plunger *8* down. When these are down the port from *d d* to the lower chamber is open and the port to the drip cup is closed.

When a flow of water occurs, the chamber of the check valve *A* opens permitting water to flow through pipe *c c* into *B*. This flow forces down diaphragm *10* and the plunger *8* which, in turn, effect the closing of the pipe to the drip cup and the opening of the port from *d d* to the lower chamber of *B;* this allows the water from *d d* to flow through this chamber into the pipes leading to the circuit closer *C* and mechanical gong *D*.

If the flow of water is small such as would be caused by water hammer or by a variation in pressure, it forces down the diaphragm for an instant only, and allows it to return to its normal position before the water from *dd* can reach the alarms; when the diaphragm goes up, the drip cup is again open and the pipe *d d* is closed, stopping the flow of water toward the alarms. If the flow of water continues, as when a sprinkler is open, the diaphragm remains down, permitting the water from *d d* to reach the devices which give the alarms.

Index of Parts, International Alarm Valve System, Fig. 120

A—*Alarm Check Valve:* *1* Body; *2* Round Cover Plate; *3* Clapper; *4* Seat; *5* Hinge; *6* Diaphragm; *7* Pin for Hinge; *8* Pin for Hinge; *9* Socket; *10* Nipple.

B—*Variable Pressure Chamber:* *1* Upper Chamber; *2* Lower Chamber; *3* Rectangular Plate; *4* Plug; *5* Intermediate Seat Ring; *6* Lower Seat Ring; *7* Conical Seat; *8* Lower Seat Plunger; *9* Spiral Spring; *10* Diaphragm; *11* Bushing; *12* Tube in Upper Chamber; *14* Drip Cup.

C—*Circuit Closer:* *1* Top Flange; *2* Bottom Flange; *3* Rectangular Plate; *4* Inspection Plate; *5* Main Cap; *6* Small Plug; *7* Long Terminal; *8* Short Terminal; *9* Knife; *10* Diaphragm; *11* Plug Inserted in Main Cap; *12* Spring; *13* Rubber Plug; *14* Porcelain Insulator.

D—*Mechanical Alarm, Water Motor, and Gong:* *1* Body of Motor; *2* Rectangular Cover; *3* Round Cover; *4* Gong Support; *5* Wheel; *8* Strainer; *10* Shaft for Wheel; *11* Bushing in Cover; *13* Shaft for Hammer; *14* Knuckles; *15* Hammer; *16* Knuckles for Hammer; *17* Pin for Knuckles; *18* Clamp Nuts; *19* Wrought-Iron Bolt; *20* Steel Gong.

Grinnell. The Grinnell straight-way alarm valve, manufactured by the General Fire Extinguisher Company, is shown in Figs.

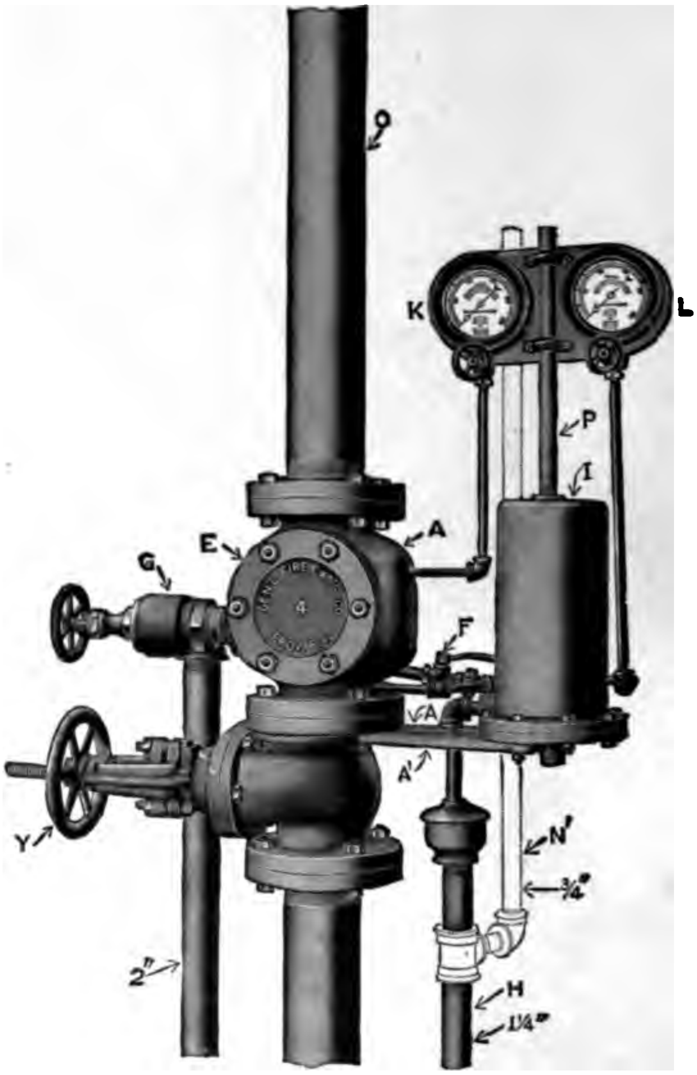

Fig. 121. Grinnell Straight-Way Alarm Valve
General Fire Extinguisher Company, Providence, Rhode Island

121 to 125. The alarm valve *A* is connected into the riser pipe *O*, as shown in Fig. 121. When a small flow of water occurs in the sys-

Index of Parts, Grinnell Variable Pressure Alarm Valve System, Fig. 121

A is the alarm valve which can be installed either in a vertical or horizontal position. *E* is a removable cover which allows of inspection or cleaning of inside of alarm valve. *F* is a ½-inch cock in pipe connecting alarm valve with drip chamber and should be wired open. *G* is an angle *L.R.D.* valve for draining system. *H* is 1¼-inch pipe for draining drip chamber. *I* is a drip chamber. *K* and *L* are pressure gauges. *M* is an electric alarm circuit closer. *N* is a vent pipe with a $\frac{1}{16}$-inch vent. *O* is the supply pipe to system. *P* is a ¾-inch galvanized pipe connecting drip chamber to water motor. *Y* is a gate valve which controls water supply to system.

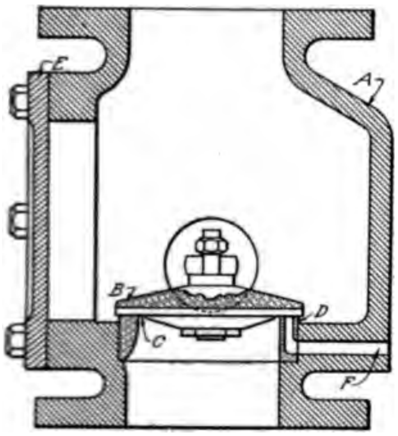

Fig. 122. Section of Variable Pressure Valve Closed

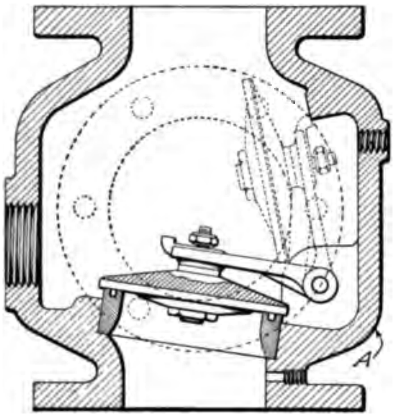

Fig. 123. Alarm Valve Showing Open Position

Index of Parts, Sections Grinnell Variable Pressure Alarm Valve, Figs. 122 and 123

A is the alarm valve which can be installed either in a vertical or horizontal position. *B* is the valve disk of alarm valve. *C* is a special renewable valve seat. *D* is an opening which allows the water to pass into the drip chamber *I*. *E* is a removable cover which allows of inspection or cleaning of inside alarm valve, and at *F* is fastened a ½-inch cock leading to drip chamber.

tem, due to water hammer or a slow leak, it raises slightly the valve-disk *B*, Fig. 122. A part of this water is allowed to go off through the side pipe *D* and the open cock *F* into the drip chamber *I*, Fig. 124, where it escapes through the pipe *H*. If, however, a sprinkler head opens, the flow of water is large and swift, which opens the valve completely as shown in Fig. 123, and the flow of water through the pipe *D* forces down the flexible diaphragm *J*, Fig. 124, to which is attached the valve *Z* which comes down until it seats against the orifice of the drip pipe. When this pipe is so closed the water fills the chamber *I* and flows out through the pipe *P* at its tip, acting upon the electric circuit closer *M*, Fig. 121, and operating the mechanical gong *R*, Fig. 125.

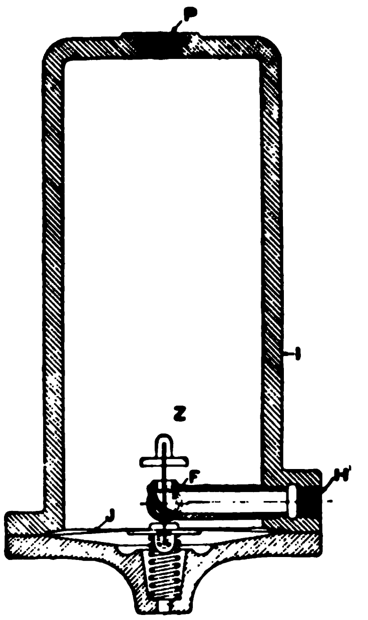

Fig. 124. Section of Grinnell Drip Chamber

Index of Parts, Section of Drip Chamber, Fig. 124

F is a ½-inch pipe and cock leading to drip chamber. *H* is a 1¼-inch pipe for draining drip chamber. *I* is a drip chamber. *J* is a flexible metal diaphragm which is forced downward (by the pressure of water when the alarm valve opens) and closes the valve *Z*. *P* is a ¾-inch galvanized pipe connecting drip chamber to water motor. *Z* is a valve which is automatically closed when alarm valve is open and prevents water escaping through drip pipe *H*.

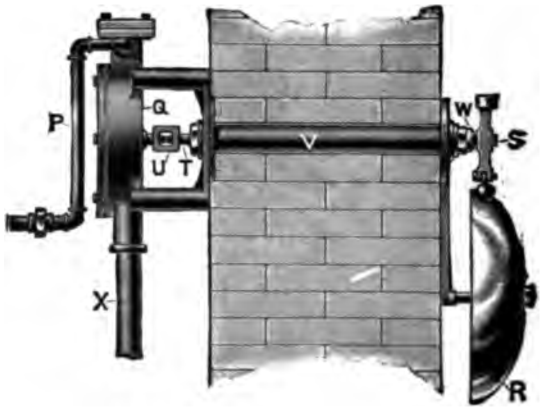

Fig. 125. Details of Grinnell Water Motor Gong

Index of Parts, Water Motor Gong, Fig. 125

P is a ¾-inch galvanized pipe connecting drip chamber to water motor. *Q* is the water motor. *R* is the gong. *S* is the striker. *T*, *U*, and *W* are connecting parts to water motor gong. *X* is a 1¼-inch pipe for draining water motor.

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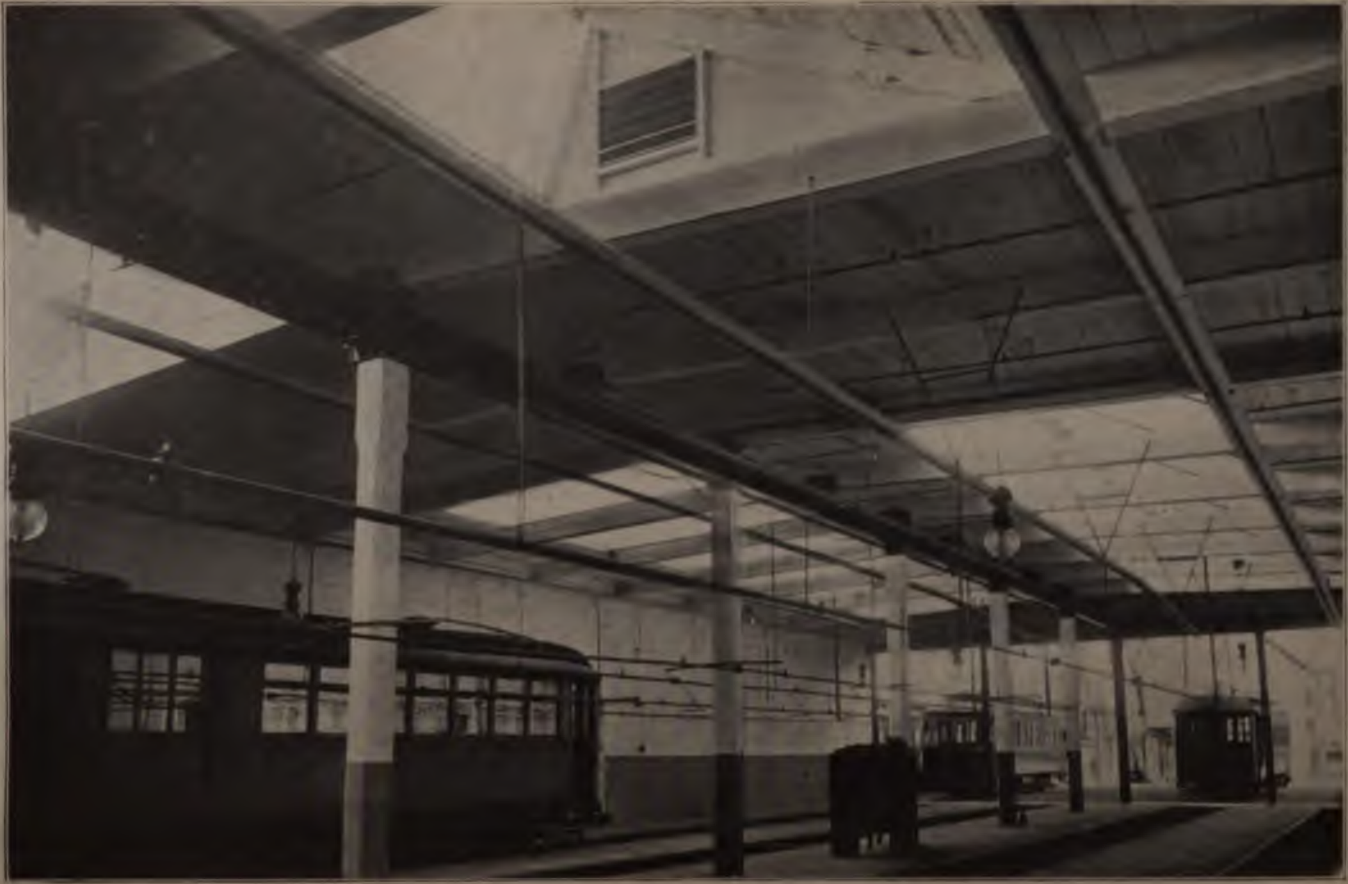


AUTOMATIC SPRINKLER EQUIPMENT FOR CAR BARNS

Is Protected by Both Aisle and Ceiling Sprinklers of the Grinnell Type. A Total of Eight Hundred Twenty-Seven Heads

Courtesy General Fire Extinguisher Company, Providence, Rhode Island

DRY VALVES

Very often buildings with sprinkler protection have no heating facilities, or certain sections of heated buildings, such as show windows, etc., may be so cold that in winter pipes filled with water will freeze. Under such conditions a so-called "dry pipe" system is used, in which that part of the piping which is exposed to dangerously low temperatures is filled with compressed air and between the air-filled pipes and the water supply is located a "dry valve," that is, a valve in which the water pressure on one side balances the air pressure on the other, thus keeping the valve closed. When a sprinkler head opens, the compressed air escapes and lowers the pressure on the air side of the valve, allowing the continued pressure on the water side to open the valve and admit water to the dry pipes. Very much depends upon the reliability of these valves which are complex in their mechanism.

A dry pipe system is not recommended and may be used only where a wet system is impracticable, yet its use is far preferable to shutting off the water supply during the winter months. Unless the proper underwriters give special permission to fill a dry pipe line with water in the summer, the air pressure should be continued throughout the year.

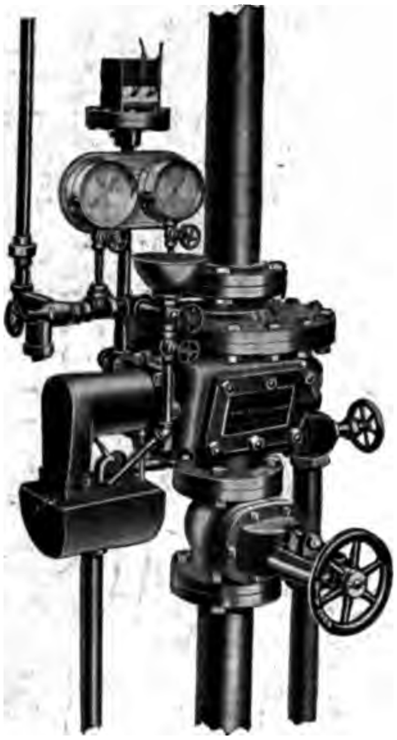


Fig. 126. Grinnell Straight-Way Dry Pipe Valve and Alarm

General Fire Extinguisher Company, Providence, Rhode Island

The number of sprinklers dependent upon one dry pipe valve should not exceed 300 and if more than this number are necessary in a building containing two or more floors the system should preferably be divided horizontally and controlled by two or more dry pipe valves. The left-hand diagram in Fig. 116 shows an approved position for attaching a dry pipe valve.

Approved Dry Pipe Valves. At the present time, the National Board approves of the following dry pipe valves: Grinnell Straightway, International (No. 4 Evans Model), Manufacturers (Model 3), Niagara (1909), Rockwood. Of these the Grinnell is approved in the 4-, 5-, and 6-inch sizes, and the others in the 4- and 6-inch sizes. These valves will be discussed in order.

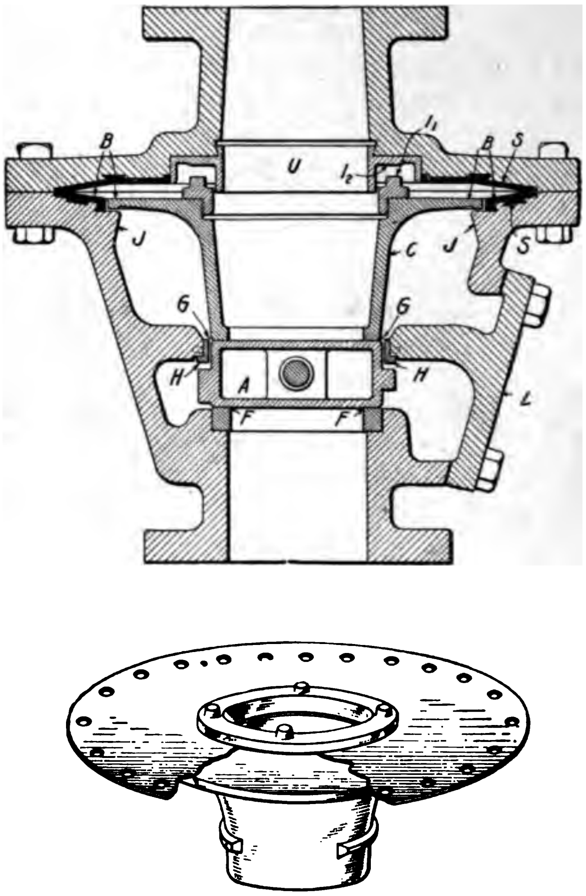


Fig. 127. Section of Grinnell Dry Pipe Valve Showing Method of Operation

Grinnell. The Grinnell straightway dry pipe valve and alarm, which is shown completely mounted in Fig. 126, and in lateral and longitudinal cross section, respectively, in Figs. 127 and 128, operates in the following manner: Sufficient air pressure is maintained in its piping system above the disk *A*, Fig. 127, to hold this disk in position against the water pressure in its pipes below *F*. If this air pressure is relieved by the opening of a sprinkler head anywhere in the system, the disk *A* and valve seat *C* are lifted by the now unbalanced water pressure until the lugs on the sides of *A* touch the stops *H;* water now flows into the intermediate chamber. When this fills, the water forces the valve seat *C* clear of *A* as indicated by the greater height of the stop *12*, Fig. 127; the water also forces the piston *D* to

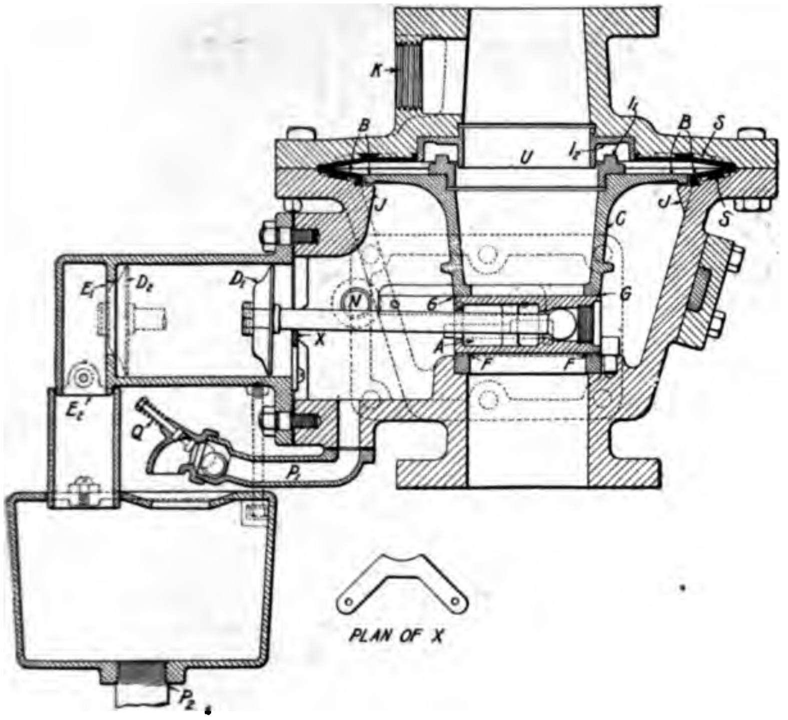


Fig. 128. Section of Grinnell Dry Pipe Valve Showing Piston and Valve Action

the left in Fig. 128, thus carrying the disk *A* entirely out of the way of the water flow. When the water fills the pipe *N*, Fig. 128, this operates the alarm.

Index of Parts, Grinnell Straightway Dry Pipe Valve and Alarm, Figs. 127 and 128

A is a round metal disk which closes the waterway; *B* is a flexible metal diaphragm which is clamped at its outer edge between the two parts of the valve body, and at its inner edge by a bronze ring screwed into C; and C is the air valve seat carried by the diaphragm B. D_1 is the piston which draws A from the waterway when valve operates; it fits loosely in a bronze tin-lined cylinder. E_1 is a vent to allow the escape from the cylinder of any water that may pass the piston; it is automatically closed as shown by D_2 after the valve has operated. E_2 is the discharge from E_1 so designed as to prevent obstructions from entering the cylinder; F is the water valve; G is the air valve; and H is a guide which limits the upward movement of the disk A. I_1 is a stop which by coming into contact with the surface I_2 limits the upward movement of C; J J are stops to support C when disk A is withdrawn; K is the draw-off valve and pipe for emptying the entire system of water; and L is a hand-hole plate which gives access to the interior of the valve. N is a pipe which connects the intermediate chamber below the diaphragm B to an electric alarm circuit-closer. When the valve opens, the full water pressure enters into the pipe N, and the pressure upon a flexible metal diaphragm closes a circuit and sounds a continuous electric alarm. The pipe N may also be connected to the Water Motor Alarm and made to sound a continuous mechanical alarm; P_1 is a ball check valve, so constructed that it allows any slight leakage of water past the valve F to flow out through the drip pipe P_2 and is automatically closed by the pressure of water in the intermediate chamber when the dry pipe valve operates. Q is a plunger to release the check and drain the body of the valve before the hand-hole plate is opened; S is a babbitt lining; U is a bronze ring; and X is a support for A after it is withdrawn from the waterway.

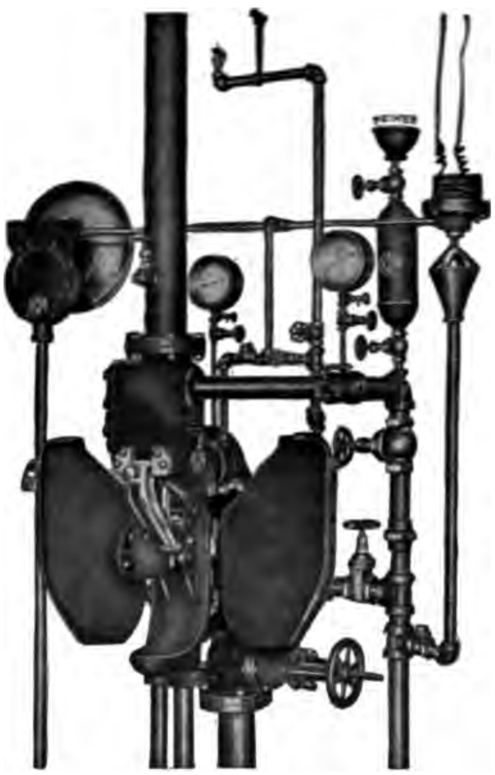


Fig. 129. International Dry Pipe Valve Set "Wet"
International Sprinkler Company, Philadelphia, Pennsylvania

International. The International dry pipe valve, Fig. 129, consists of a main body, divided into an upper chamber containing nor-

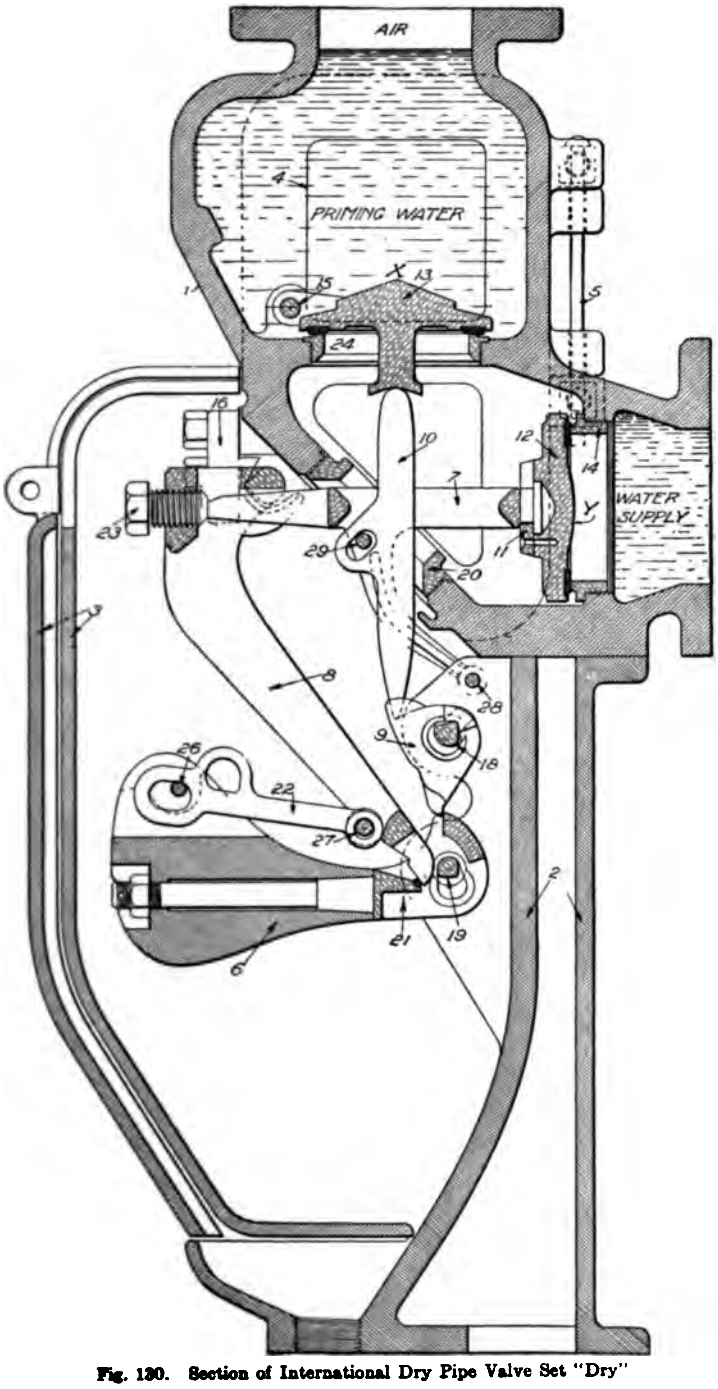


Fig. 130. Section of International Dry Pipe Valve Set "Dry"

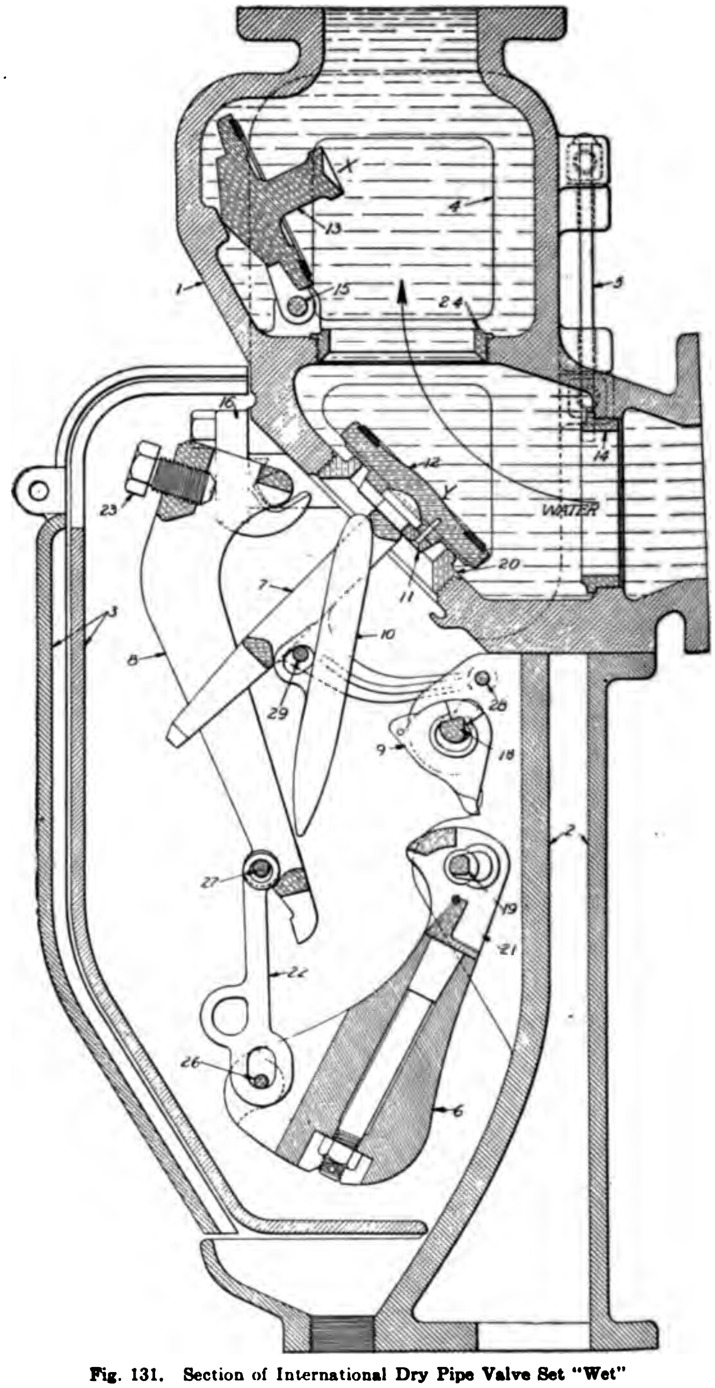


Fig. 131. Section of International Dry Pipe Valve Set "Wet"

mally compressed air, an intermediate chamber which is under atmospheric pressure when the valve is "set," and a third (water intake) chamber which is normally closed by a swinging check *Y*, shown in place in Fig. 130. The same diagram shows also the valve *X* in position when the valve is set "dry." When the air pressure above the priming water is reduced to nine pounds by its opening of a sprinkler head, this allows the weight *6* and the water pressure in the supply pipe to force the pin *10* and valve *X* upward; this releases tumbler *9;* and weight *6*, being no longer supported, drops down so as to allow the arm *8* to release the valve stem *7*. The rush of water seats valve *Y* on the seat ring *20* as shown in Fig. 131, throws valve *X* back out of the way, and fills the sprinkler pipes.

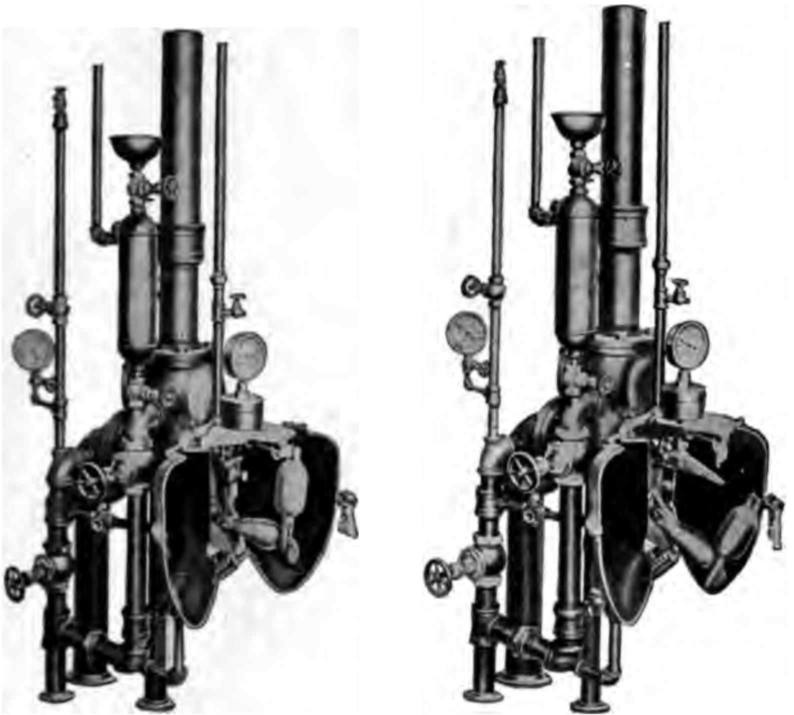


Fig. 132. Manufacturers' Dry Pipe Valve. Two Views Showing the Valve "Set" and After It Has Operated
[*Automatic Sprinkler Company of America, New York*

Index of Parts, International Dry-Pipe Valve, Figs. 130 and 131

1 Body; *2* Foot Casting; *3* Right and Left Cover; *4* Cover Plate; *5* Rivet; *6* Ball Weight; *7* Fork; *8* Hook; *9* Tumbler; *10* Strut; *11* Plate; *12*

Clapper for Water Seat; *13* Clapper for Air Seat; *14* Water Seat Ring; *15* Pin; *16* Left Bracket; *18* Top Pin; *19* Bottom Pin; *20* Outer Seat Ring; *21* Head for Ball Weight; *22* Connecting Rod; *23* Adjusting Screw; *24* Air Seat Ring; *26* Pin; *27* Pin; *28* Pin; *29* Pin.

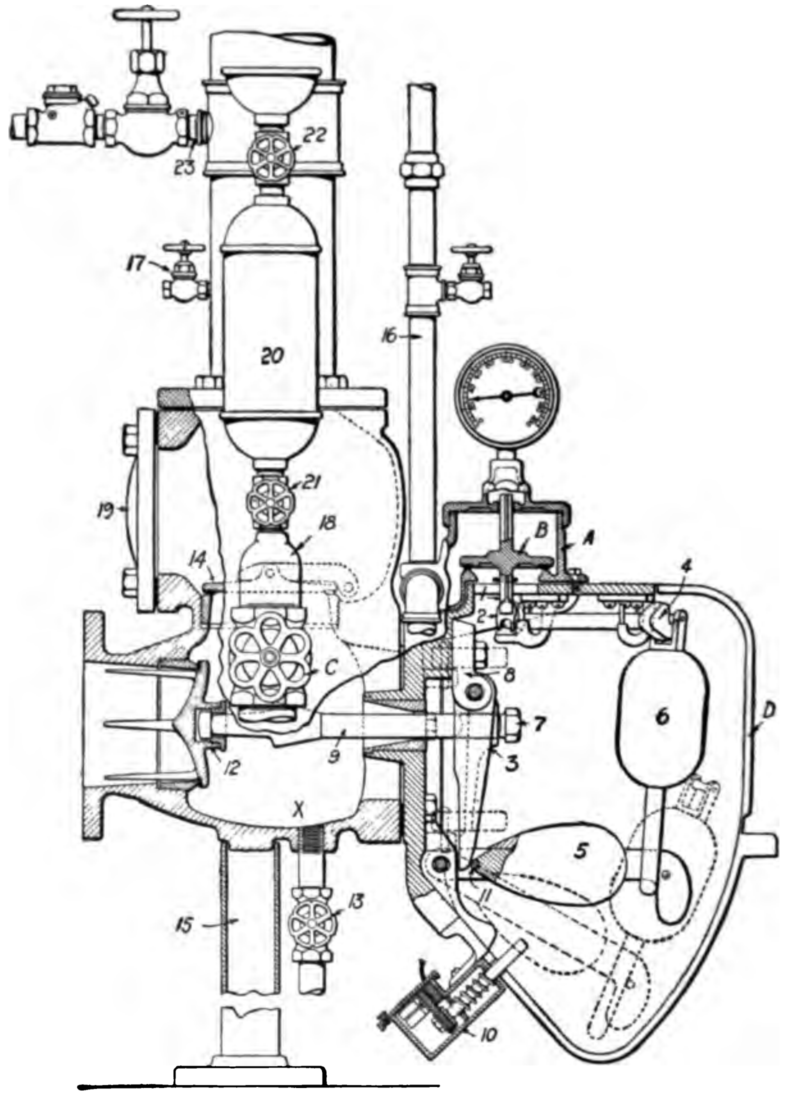


Fig. 133. Manufacturers' Dry Pipe Valve in Part Section

Manufacturers' Model 3. The Manufacturers' dry pipe valve, o views of which are shown completely assembled in Fig. 132 and e in part section in Fig. 133, operates as do the others already scribed by the opposition of the water pressure outside of valve *12* d the air pressure in the pipe system above valve *14*. *X* represents intermediate dry chamber which contains neither compressed air r water. Valve *12* which holds back the water is kept closed by a stem of levers and weights held in place by the air pressure of the disk *B*. When this pressure is released, the raising of disk *B* ows the weights to drop and piston *9* is forced back by the water essure. The weight *5* drops against the circuit closer *10* and sends an alarm. When the water valve *12* is open, the rush of water ens the air valve *14* permitting the water to enter the system. The mpressed air is pumped into the main system at the inlet *23*, and ches *B* through the auxiliary pipe *16*, which pipe is also used for sting purposes to see whether or not water has leaked into the stem. The water which is used to seal or prime the air valve is mitted through the cup above *22*.

Index of Parts, Manufacturers' Dry Pipe Valve, Fig. 133

Air Cup; *B* Air Disk; *C* Drain Valve; *D* Doors; *X* Intermediate Chamber; *1* Air Disk Stem; *2* Rolling Pin Disk; *3* Yoke Lever; *4* Releasing Lever; *5* Horizontal Weight Lever; *6* Vertical Weight; *7* Adjusting Screw; *8* Main Hinge; *9* Stem of Water Valve; *10* Circuit Closer; *11* Contact Pin; *12* Water Valve Disk; *13* Drain to Intermediate Chamber; *14* Air Clapper; *15* Support; *16* Anti-Water Column Air Test; *17* Riser Air Test; *18* Main Drain Outlet Tree; *19* Hand-Hole Cover; *20* Priming Chamber; *21* Rising Priming Valve; *22* Funnel Valve; *23* Air Inlet Pipe.

Niagara. The Niagara dry valve is shown in part section in g. 134, the air valve being marked *X*, the water valve *Y*, and the disk *Z*. The air pressure on disk *Z* keeps in position a series of ights and toggle joints *12*, *33*, *11*, *9*, *7*, *4*, etc., which keep the ve *Y* closed. When the pressure is released at *Z*, the weights drop, wing the piston *7* and the toggle joints to move and open the ve *Y;* the water rushes in, fills the chamber *1*, forces open the eck valve *X*, and thus enters the system.

Index of Parts, Niagara Dry Valve, Fig. 134

Air Supply; *B* Air Pipe Drain; *C* Check Drain; *D* Priming Cups; *E* Air Pipe to System; *F* Priming Test Valves; *X* Air Valve; *Y* Water Valve;

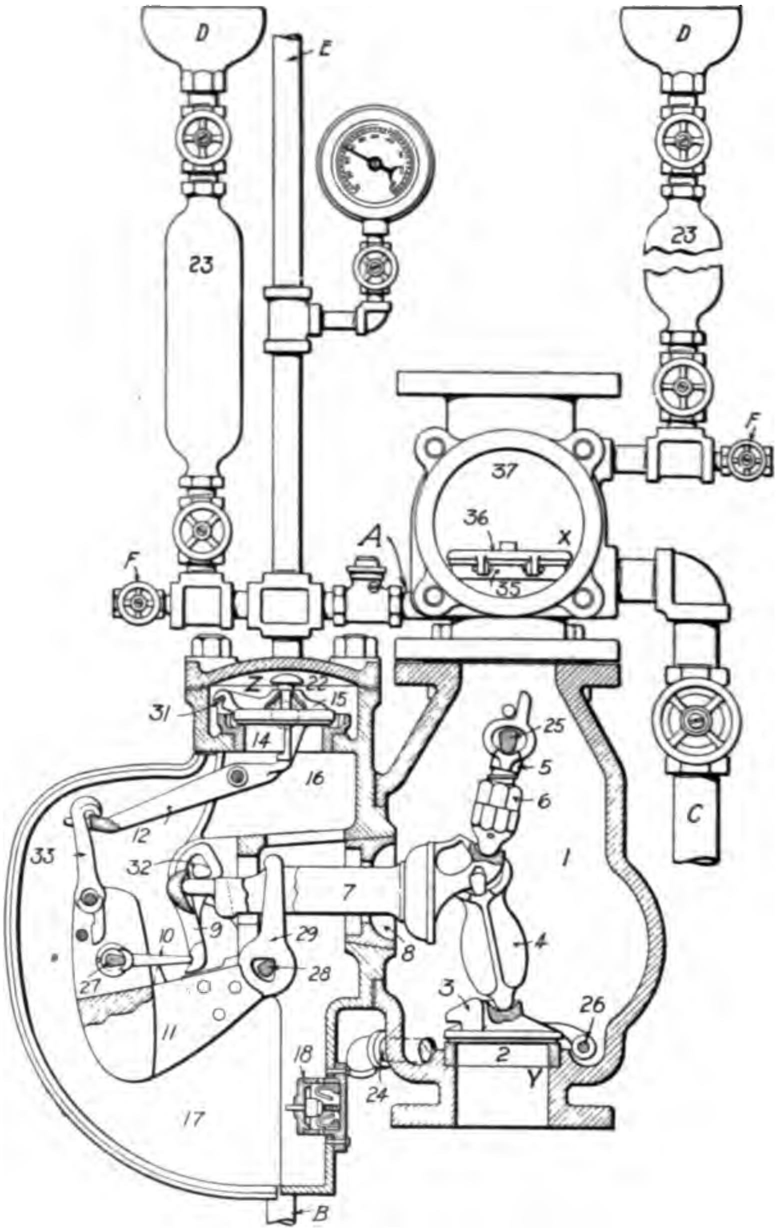


Fig. 134 Section of Niagara Dry Pipe Valve
Niagara Automatic Sprinkler Company, Akron, Ohio

Z Air Disk; *1* Valve Body; *2* Valve Seat; *3* Valve Clapper; *4* Lower Toggle Strut; *5* Upper Toggle Strut; *6* Toggle Stress Nut; *7* Plunger; *8* Plunger Seat Bushing; *9* Fulcrum Lever; *10* Horizontal Strut; *11* Weight; *12* Trip Lever; *14* Trip Lever Seat; *15* Trip Lever Disk; *16* Trip Lever Pot; *17* Left-Hand Door; *18* Alarm; *22* Air Pot Cover; *23* Priming Chamber; *24* Ball Drip; *25* Upper Strut Pin; *26* Water Seat Pin; *27* Horizontal Strut Pin; *28* Weight Pivot Pin; *29* Weight Lever; *31* Air Pot Disk Pin; *32* Fulcrum Lever Studs; *33* Weight Hook; *35* Check Valve Seat; *36* Check Valve Disk; *37* Check Valve Body.

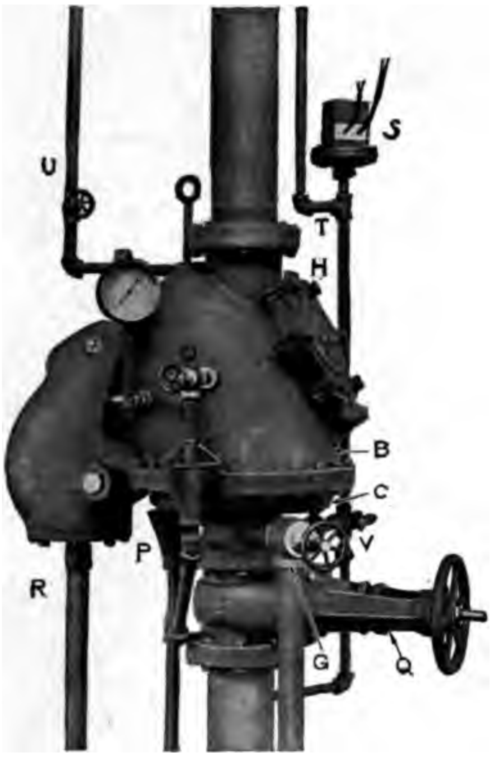


Fig. 135. Rockwood Straight-Way Dry Pipe Valve
Rockwood Sprinkler Company, Worcester, Massachusetts

Rockwood. In the Rockwood straightway dry pipe valve, which is shown complete in Fig. 135 and in section in Fig. 136, the valve plate *A* is held in place by the air pressure acting on the surface of the priming water. When this pressure is relieved by the opening of a sprinkler, the upward pressure of the water underneath the valve plate *A* lifts it, allowing the water to rush in and push the whole valve out of the way, as shown by the dotted position A_2 FE_2.

Index of Parts, Rockwood Straight-Way Dry Pipe Valve, Figs. 135 and 136

A_1 is a bronze valve-plate which both closes the water inlet *J* and seals the air-valve chamber by the contact of the rubber ring at its circumference on a block tin air-valve seat *I*; *B* is the upper part of the valve body, in which the valve-plate *A* swings when it opens the water inlet; *C* is the lower part of the valve body, and carries the air and water seats; *D* is a swinging arm, to which are attached the valve-plate *A* and the counterweight *E*; the whole swings about the axis *F* as the valve opens to the position A_2E_2F; *E* is an iron ball filled with lead. The weight of the valve-plate *A* tends to hold itself down on its two seats when shut, and the weight of the ball tends to hold the valve-plate open after it has started to open; *G* is the draw-off valve and pipe for emptying the entire system of sprinklers and piping. It is also a test valve to determine the vigor of the water supply; *H* is the hand-hole cover plate, for giving access to all interior parts of the valve; *I* and *J* are the tin air seat and bronze water seat, respectively; *K* is a projection on the ball *E* adapted to engage a gravity latch *L*. It is brought into use to prevent the valve-plate from returning to its seats if the combination should occur of (1) a feeble water supply; (2) a corroded or jammed spindle *F*; (3) a reversal of flow after the riser had been filled with water. Under normal conditions, it plays no part, *M* is a ball-seated swing check-valve which is

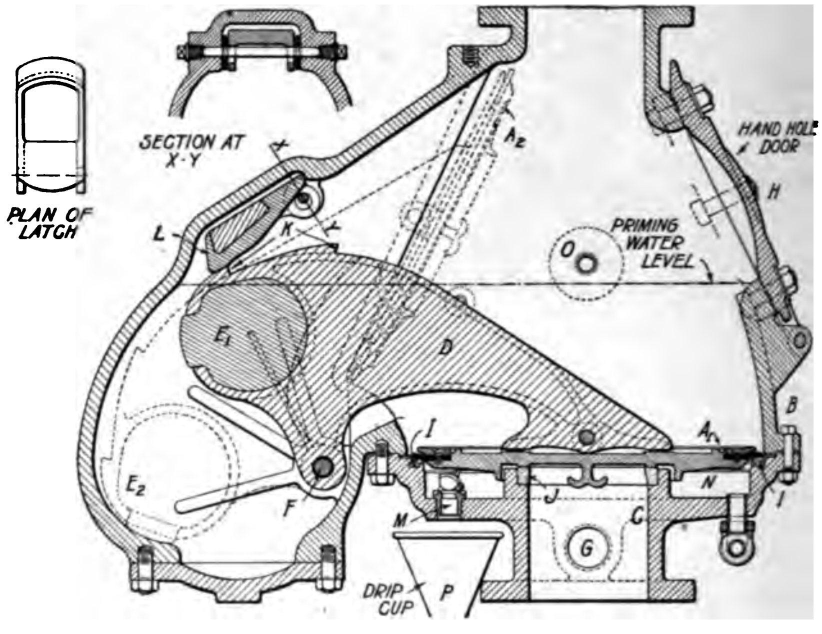


Fig. 136. Section of Rockwood Dry Pipe Valve

automatically held off its seat by the contact of its arm extension with the under side of the valve-plate, and thus allows any water which may leak by *J* to run freely out of the intermediate chamber *N* into the drip cup *P*; *O* is a valve communicating with the body *B* at a point just above the priming water level, and its use is to show that there is no water in the system above this point; *P* is a drip cup; *Q* is the main gate valve; *R* is a jack for raising the lip of the upper body *B* over the flange of the under body *C* when it is desired to remove *C* or *A* for repairs. To use the jack, hold the pipe post *R* with one pipe wrench while screwing upwards the coupling at the upper end of *R* with another wrench; *S* is an electric alarm circuit-closer; *T* is a pipe connecting with a water motor alarm; *U* is a valve controlling supply from air pump; *V* is a three-way cock for convenience in testing the circuit closer *S*.

Air Supply. The air pumps to these systems should be steam- or electrically-driven and of sufficient capacity to increase the air pressure at least one pound during each two minutes pumping. The air supply should be drawn through a screened intake from a dry room so as not to carry moisture into the dry pipes. The pipe connection from the air pump to the dry pipe valve should be provided with a shut off valve and immediately back of it a check valve.

Test Pipe. Under each dry pipe valve there should be a two-inch drain pipe with a shut-off valve to be used by inspectors or whenever it is desired to determine whether the water in the system is up to the dry valve.

Protection. These dry valves, if exposed to the cold, should be located either in an underground pit or enclosed in a closet of sufficient size to give 2½ feet free space on all sides and at the top and bottom of the valve. These closets should have double-walled tops, bottom, and sides; between the walls there should be a 4-inch space filled with mineral wool, tan bark, or some other packing. They may be heated by steam, a lard oil lantern, a gas heater, or a properly installed electric heater.

Flanged Dummy. It is necessary at times to remove the dry valve for repair and, in order that the piping system may be complete while this repair work is being done, a flanged section of pipe just fitted to take the place of the dry valve should be provided.

Drainage. The proper drainage of a dry-pipe system should receive especial attention so that no water can remain in the pipes to rust them, or to damage them by freezing. For this reason the slope of the ceiling pipes in a dry system should be at least ½ inch to 10 feet, while on wet lines it need not be greater than ¼ inch to 10 feet.

Sprinklers on dry lines must *never* be pendent, but always upright so as to be thoroughly drained.

MAINTENANCE OF SPRINKLER SYSTEM

Installation of Sprinklers. When installing a sprinkler system the plans, which are usually made by the companies furnishing the heads, should be submitted for correction and approval to the underwriters having jurisdiction, and the work of putting in the equipment, which is a trade in itself, should be trusted only to fully experienced and responsible parties.

Care and Supervision. After completion the sprinkler system should be most carefully maintained, some competent person on the premises being given the care of it and held responsible for its condition. The property owners and the insurance companies interested should see that the system is regularly inspected. When any fitting leaks or becomes deranged, it should be repaired immediately, for the plugging up or the removal of any parts of the equipments is not allowed. Whenever it is necessary to turn off the water or in any way modify the protection given by such a system the company who carries the insurance should be notified.

The circulation of water in the sprinkler pipes is objectionable as it increases the corrosion, the deposit of sediment, and the condensation drip from the pipes; consequently, such circulation is prohibited above the base of the riser.

Central Station Supervision. The best assurance that everything pertaining to a sprinkler system is kept in proper working order is obtained by installing a system of electric alarms which are connected with a central station established for the purpose of supervising sprinkler equipments.

In most large cities there are one or more such stations which make a business of installing electrical devices attached to the valves, tanks, pumps, etc., of a system, so that the station will automatically receive notice of any change in the system. This notice is either transmitted electrically to the fire department as a fire alarm or communicated by telephone or messenger to the person in charge of the sprinkler system, the property owner or the insurance company, so that the trouble may be attended to. When the trouble is set right, an alarm of a different character is received at the central station, denoting that normal conditions are restored.

These alarm devices—those which meet the National Board's approval are controlled by the National Telegraph Company—give an alarm whenever a gate valve is closed or opened; whenever the level of the water or the pressure of the air falls below, or is restored to, the desired point; and whenever the water in a tank reaches a dangerous temperature—either too hot or too cold. Any water flow amounting to the discharge of a single sprinkler head gives an alarm within a few seconds. These few seconds are allowed so that variable pressure and water hammer will not give false alarms.

A daily report is issued of all the alarms received, together with what they indicated when they were received, and when the wrong condition was corrected.

Besides this, these central stations make a semi-monthly inspection of the entire sprinkler system and of their own devices, to see that they are in proper order to act promptly and reliably. Many of these automatic alarms are also fitted with a "tamper" alarm, so that notice will be automatically given of any injury, accident, or misuse.

Care of Sprinkler Heads. Whenever the pipes are bronzed over or painted for appearances, the movable parts of the sprinklers must not be so coated or their sensitiveness will be impaired. The sprinkler heads must be most carefully watched to see that no accident, corrosion, or other cause, renders them inoperative. At least six extra sprinkler heads should be kept on the premises to replace any fused by fire or in any way injured..

Life. There are on the market several preparations of more or less merit for covering the sprinklers to prevent their becoming corroded, and most companies are prepared to coat their own heads with some protecting preparation. Yet serious corrosion of heads often occurs when the process of manufacture or the kind of goods stored in the building renders the presence of either acid or alkaline fumes liable. Such corrosion is most frequently found in paper mills, chemical plants, glucose and starch plants, carbonizing or wool extracting works, dye and galvanizing works, and in fur dressing or cutting establishments.

When a head becomes corroded the movable parts stick together and the solder itself often becomes involved. This last is less likely to occur in sprinklers in which the solder is between two pieces of metal and is, therefore, but slightly exposed. In sprinklers of other designs, where the solder is largely exposed, the corrosion in some cases may so change its character as to harden it, and in other cases it may change it into a weak crystalline form easily broken by water hammer.

The corrosion of heads with the present preparations for coating them is not so serious a problem as the incrustation of sprinklers, which occurs in flour and cement mills, grain elevators, saw mills, sugar refineries, and other places where dust is constantly rising. The mere coating of dust does not seriously affect the sprinkler, yet, when sufficient moisture is present, the fine dust soon hardens into a crust about the sprinkler, rendering it entirely inoperative.

A deposit of another nature forms on heads in rooms where artificial heat is employed for drying, such as in oil cloth factories, patent leather works, rubber works, etc. Particles of oil and varnish settle on the sprinklers and are baked there by the heat of the room into a tough, hard coating seriously affecting the sensitiveness of the head.

Glass caps which cover all but the base of the sprinkler have been used to protect them from deposits, yet these are not successful, as they likewise act to keep away the air heated by a fire.

If an inspector has doubts as to the condition of any sprinkler heads, he should take a few samples to test. A rough preliminary test may be given by immersing the heads in boiling water where they should snap open within 30 seconds. If they fail to do this they should be given a more careful test in a suitable oven.

Tests. There are two methods of testing sprinkler heads, one to determine the fusing point and the other to determine the sensitiveness, or the comparative quickness with which it responds to the action of heat. Since all sprinklers, except those of high fusing point, use practically the same solder, the sensitiveness of a head depends largely upon the position of the solder and the amount used, for it is evident that a small amount of solder well exposed would become melted more quickly than a larger amount more or less concealed. To find the exact fusing point the head should be immersed in a large quantity of fluid, into which are hung thermometers, with their bulbs near the fusible part of the sprinkler. The fluid should be heated very gradually, and the time at which the sprinkler drops apart should be noted.

Since sensitiveness is a comparative matter, the several heads to be tested, that is, the old and corroded heads and the new ones of the same type, should be put in the oven at the same time and the temperature raised gradually as would occur at an ordinary fire. By watching the sprinklers the comparative speed with which they respond to the heat can be determined. To get accurate results from this test the oven should be constructed so as to insure uniform heating and correct thermometer readings.

If the necessary apparatus is not at hand for testing, doubtful heads should be sent to the insurance companies interested or to some laboratory where it can be done.

Records of Sprinkler Risks. Considering the complexity of a sprinkler equipment, the necessity of every part being in proper order, and the deterioration which often occurs in the heads, the records of fires which sprinklers have extinguished are wonderful. The statistics for the year beginning March, 1910, are as follows:

Fires in sprinklered risks sprinklers opened	Unsatisfactory results
1086	37

This shows failure in only 3.4 per cent of the cases. The causes of the unsatisfactory showing in the 37 cases have been tabulated as follows:

	No. of Fires
Water shut off sprinklers	7
Generally defective equipment and unsprinklered portions	9
Defective water supply or supplies	3
Exposure or conflagration	4
Hazard of occupancy too severe for average sprinkler equipment	2
Obstruction to distribution	2
Faulty building construction, concealed space, vertical openings, etc	1
Explosion crippled sprinkler system	1
Sprinkler system crippled due to freezing	1
Slow operation of dry system or defective dry valve	1
Slow or defective operation of high test heads	..
Miscellaneous	4
Not classified	2
Total	37

The effect of the installation of automatic sprinklers in manufacturing risks may be judged from the fact that the rates on buildings which have been equipped with approved sprinkler systems have been reduced to but a small part of what was originally charged. For example, the rate on unprotected cotton mills used to be about three per cent, whereas now the rate on cotton mills in which sprinklers are installed is as low as one-tenth of one per cent.

OUTSIDE SPRINKLERS

Development of Design. Outside, window, or cornice sprinklers are designed to protect a building against exposure hazards. The conditions under which these sprinklers work and the service required of them necessitates a head of a very different design than the automatic sprinklers just described.

Like the automatic sprinklers these outside heads have passed through a long history of development. Perforated pipe was first tried for outside protection, but the perforations clogged easily and, unless the pipe was very large and the amount of water used excessive, that part of the pipe line nearest the riser discharged most of the water while but little reached the end of the pipe. Much of this water was sprayed upon the incombustible brick walls of the building while the windows, the points most in need of protection, received no extra share. The earliest types of cornice sprinklers were an improvement over perforated pipe in that they localized the densest part of the shower over the vulnerable parts of the building. Still they had the same sized orifices and deflectors as those of the inside sprinklers, so that the water was sprayed over a circular cross section

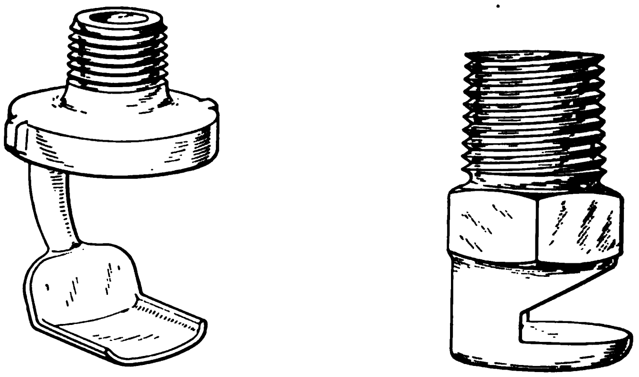


Fig. 137. Two Forms of Outside Sprinkler Heads

TABLE III

Size of Orifices for Window Sprinklers

	2 Lines	3 Lines	4 Lines	5 Lines	6 Lines
Top Line	$\frac{3}{8}$ inch	$\frac{3}{8}$ inch	$\frac{3}{8}$ inch	$\frac{3}{8}$ inch	$\frac{3}{8}$ inch
Next low	$\frac{5}{16}$ inch	$\frac{5}{16}$ inch	$\frac{3}{8}$ inch	$\frac{3}{8}$ inch	$\frac{3}{8}$ inch
Next low		$\frac{1}{4}$ inch	$\frac{5}{16}$ inch	$\frac{5}{16}$ inch	$\frac{5}{16}$ inch
Next low			$\frac{1}{4}$ inch	$\frac{5}{16}$ inch	$\frac{5}{16}$ inch
Next low				$\frac{1}{4}$ inch	$\frac{1}{4}$ inch
Next low					$\frac{1}{4}$ inch

and much of it was lost by being sprayed into the air. The orifices in outside sprinklers are not sealed and their action is not automatic so that when the water is turned on it flows from all the heads at once. Experience showed that if the orifice was made smaller—from $\frac{1}{4}$ to $\frac{3}{8}$ inch in diameter—the amount distributed by the first and the last sprinkler on a line would be more uniform and the pressure throughout would be better; it was also found that it was best, where there were several lines of outside sprinklers on a building, to have the orifices of the heads on the top lines larger than the orifices in the lower ones.

The shape of the deflector has also been corrected, as indicated by the two types of outside sprinklers shown in Fig. 137. It will be noticed that the deflector is designed to spray the water down and against the building.

Window Sprinklers. The National Board of Fire Underwriters specify that windows not exceeding 5 feet in width should be protected by one sprinkler placed in the center near the top in the best position to thoroughly wet the entire window. For windows of greater width and in cases where mullions interfere with the distribution of the water two sprinklers should be used.

Size of Orifice. When there is but one horizontal line of window sprinklers each head should have a smooth bore tapering outlet with an unobstructed orifice $\frac{3}{8}$ inch in diameter. If the building requires more than one line the size of orifice to be used is as given in Table III. Where there are over six lines of windows, the sprinklers may often be omitted in the first and sometimes on the second floor. If over six lines are necessary, the system thould be divided horizontally and each division fed from separate risers.

TABLE IV

Number of Sprinkler Heads for Different Size Pipe

Sprinkler Orifice ⅜-inch	Sprinkler Orifice 7/16-inch	Sprinkler Orifice ½-inch
1 head on ¾-inch pipe	1 head on ¾-inch pipe	1 head on ¾-inch pipe
2 heads on 1-inch pipe	3 heads on 1-inch pipe	5 heads on 1-inch pipe
4 heads on 1¼-inch pipe	6 heads on 1¼-inch pipe	6 heads on 1¼-inch pipe
6 heads on 1½-inch pipe		

Risers. Either the risers may feed the pipes from the center as shown in Fig. 138, or there may be two risers, one at each end, and the sprinkler pipes run between them, forming a gridiron system, Fig. 139.

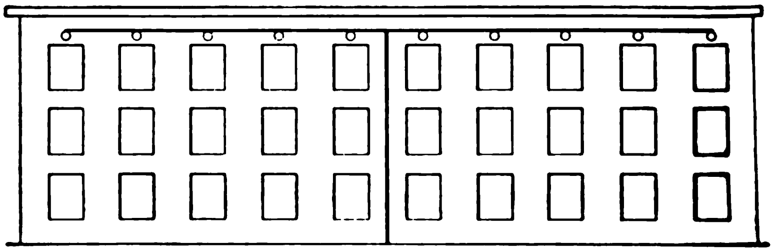


Fig. 138. Outside Sprinkler Piping System with Single Central Riser

With the central riser method of feeding, no branch line may have over six heads and with the gridiron system, twelve are the most allowed on each pipe. The pipe sizes should be as given in Table IV.

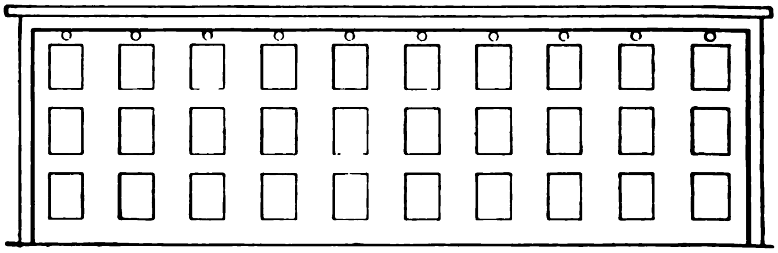


Fig. 139. Outside Sprinkler Piping System with Side Risers

The size of the feed mains and risers in the central riser system shall be determined as in Table V.

TABLE V

Sizes of Feed Mains and Central Feed Risers

1½ inch—Not over 6 heads	3 inch—Not over 36 heads
2 inch—Not over 10 heads	3½ inch—Not over 55 heads
2½ inch—Not over 20 heads	4 inch—Not over 72 heads

If the system is gridironed the above figures may be used by counting the number of heads to the center of the pipe as the number of heads supplied by each riser.

The size of the mains necessary to feed the risers should also be determined from Table V, although, if the length of any main—including the length of the riser as far as the first branch—is more than 25 feet, the main should be at least a size larger than required by the table. In cases where there is more than one riser, the proper underwriters should determine the size of the mains, which in any case should never be smaller than the full equivalent of the two largest risers.

Pipes and Fittings. All the pipes and fittings as far back as the cast-iron supply mains should be of the most carefully galvanized wrought iron or other approved material, and all of it should be thoroughly inspected before it is installed. When installed all the pipes should be supported as securely as is required for inside work, and like inside pipes they should be so pitched that the whole outside system, as far back as the inside valve which controls the water supply can be drained. The drip pipe provided should be of the same size as that required for inside sprinklers.

Valves. The valves necessary in an outside system are simply those to admit or cut off the water supply. If central risers are used each riser should have a separate controlling valve. When side-feed risers are used they should be connected at the bottom and should have but one valve so located as to control both risers. The design of these stop valves should be the same as that required for inside sprinklers, and each valve should be distinctly marked in half-inch or larger letters to denote its use. These riser valves should be located in an accessible place, preferably not above the first story.

In case the outside sprinklers are ineffectual, it is often best to shut the water off from them and devote it to other purposes. For this reason there should also be a controlling valve at some safe distance from the sprinklers where it could be used during an exposure fire. The best place for such a valve is outside the building on the side opposite to that protected by the sprinklers. If a steamer connection is provided, that too should be similarly located at a safe distance, and protected so that it might be used during a fire. These valves may be located in a valve room properly cut off or in a pit, according to the decision of the underwriters having jurisdiction. If they are underground they should be in approved pits accessible through manholes or else fitted with approved post indicators.

Gauge Connections. Both at the top of each riser and at a point just below the controlling valve outlets should be piped into the building and plugged, in order to provide for the attaching of a test pressure-gauge.

Water Supply. The water may be supplied to outside sprinklers from the public mains, from a pump, standpipe, reservoir, or steamer connection; but never from the gravity or pressure tank which supplies the automatic sprinklers, except in case the gravity tank has an excess capacity which only can be drawn off for this purpose. If any supply to outside sprinklers feeds other water distributing device such as hydrants, inside sprinklers, etc., the system should be arranged so that the outside sprinkler supply could not be obtained at the expense of diminishing the supply to the other appliances. The water supply should be of sufficient capacity to feed both the outside sprinklers and the other devices at the same time, and also sufficient to feed all the sprinklers designed to operate at one time and maintain not less than 10 pounds pressure at the top of the riser for at least one hour.

Cornice or Ridgepole Sprinklers. A line of open sprinklers is often used to protect the mansard roof of a brick building, or to protect low frame buildings. For such purpose the heads should have orifices $\frac{3}{8}$ inch in diameter and should be spaced not over 8 feet apart on the line, and the pipe sizes and arrangement of the heads should be the same as those required for window sprinklers.

If the capacity of the water supply will admit sprinklers with $\frac{7}{16}$-inch or $\frac{1}{2}$-inch orifices, pipe sizes at least as large as the following specifications should be used:

1 head on 1-inch pipe
3 heads on 1¼-inch pipe
5 heads on 1½-inch pipe
8 heads on 2-inch pipe

Frame buildings over two stories high are best protected by two or more horizontal lines of sprinklers, one line at each of the upper stories, beginning at the eave line, and if the windows are not over 8 feet center to center the heads should be located over them.

Protection of Outside Sprinklers. The "water curtain" obtained from outside sprinklers is sufficient to protect a building during its exposure to fires of ordinary severity. In the case of a conflagration, however, or when a fire is very close, the heat may be sufficient to turn this thin film of water into steam, in which case the inside sprinklers will operate. Outside sprinklers, although a great help, are not sufficient protection to be used in preference to fire shutters. In conjunction with them, however, a barrier is produced that fire can scarcely cross.

STANDPIPES

Advantages. Except for the automatic sprinkler which as yet is but little used in office buildings, modern fire-fighting apparatus is inadequate in tall structures. The pressure necessary to force water to any considerable height will break the ordinary fire-department hose and, furthermore, the carrying of hose into high burning buildings is a slow and dangerous task.

The best assurance of a good and prompt supply of water in the upper stories is to equip a building with a standpipe fire line, which in general is a large metal pipe extending from the cellar to the roof, and provided with hose outlets at each floor, so that the water supply admitted to the standpipes may be converted into hose streams at any floor. The necessity for some such aid to fire fighting in tall buildings and in those of great area is so great that cities usually make it a requirement. Schools, hotels, asylums, and business blocks, wherever located, should be fitted with these lines.

Size of Pipe. In buildings not more than 150 feet high, the standpipe should be 4 inches in diameter, higher buildings require standpipes 6 inches or more in diameter. The pipe itself should be of wrought iron or steel of standard quality and strong enough to endure the pressure necessary to force adequate streams of water through it to the roof. All of the fittings must be of wrought iron, never of cast iron. All the joints must be screwed joints made thoroughly tight with red lead. Offsets and bends should be avoided wherever possible, and wherever bends are necessary they should be of a radius equal to five diameters of pipe.

The standpipe must rest on brick pier foundations or must be suspended from the floor beams by heavy iron hangers, and it must be securely stayed and braced at each floor to withstand vibration. When more than one standpipe is installed, cross pipes as large as, or larger than, the main risers should connect them in the basement. All the horizontal supply lines must be hung from the floor beams by heavy iron hangers spaced no more than 10 feet apart.

To the standpipe there must be an outside two-way, 3-inch, fire department connection fitted with clapper valve and caps. This connection should be above the curb on the street front of the building where it can be easily used by the fire department. At each floor level, and if possible within the stairway enclosures, there should be a 2½-inch hose outlet, of regular fire department pattern fitted with some type of controlling valve—preferably a gate valve. Attached to these outlets and arranged on approved racks or reels, there should be sufficient 2½-inch standard fire hose to adequately cover each floor. Approved open or controlling nozzles should be attached to the hose.

Water Supply. The water supply to such a system may be pumped in, or if the pressures are adequate, it may come from the city mains, or it may be supplied from a gravity or pressure tank. According to its water supply the standpipe should be fitted with a check valve at its top or bottom, and at both top and bottom if supplies enter at both ends. For high buildings and for such buildings as schools, hospitals, theaters, and business blocks, two supplies should always be provided. If a gravity supply is used, the bottom of the tank should be elevated at least 20 feet above the highest hose outlet and the tank capacity should be not less than 3,500 gallons. If the domestic supply is drawn from the same tank, the pipe from which it is drawn should enter the tank at a sufficient height from the bottom to prevent the domestic supply from drawing down the water to a level below that required for the standpipe supply.

Installation. When a standpipe is being installed in a building in the course of erection, it should be carried up with each floor and kept in condition for use after the structure becomes too high (6–7 stories usually) to be easily covered with the local fire department equipment.

To prevent dirt and building materials falling into the pipe and obstructing it, the top of the standpipe should be capped at all times when work on it is not going on at that point.

In all cases the equipment should be built according to plans corrected and approved by the local building authorities and insurance underwriters.

PERFORATED PIPES

In the past perforated pipe has been used for both inside and outside protection, though in most cases with but poor success. At the present time its use is largely confined to the protection of places which in time of fire, on account of the smoke and poor ventilation, would be reached with difficulty, such as cellars, subcellars, coal chutes, and shaving vaults. The water supply to these pipes is pumped into them by the city fire department. Although in any particular case the local building laws and insurance authorities must govern the details as to the pipe to be used and the way it is to be installed, results have shown that a system approximating the following is most satisfactory.

Pipe System. *Pipe.* The pipe and fittings should never be of cast iron; the former may be either of wrought iron or of steel able to withstand a pressure of 300 pounds to the square inch. Pipe of 1½-inch internal diameter is best. Running lengthwise on each quarter of the pipe's circumference there should be a line of $\frac{1}{16}$-inch holes drilled, not punched. The holes in the separate lines should be 2 inches apart, and so placed that those on one line will come opposite points half way between the holes of the adjacent lines, or as it is most commonly expressed—the holes or adjacent lines should be "staggered." Such an arrangement makes 24 perforations to the running foot of pipe.

Installation. The system consists of parallel lines of such pipe suspended by iron hangers from the ceiling so as to be parallel to and at least 6 inches below it. In order to withstand vibration and jar these pipes must be securely braced and fastened. These overhead lines should run the entire depth of the building about 12 feet apart, measured from center to center, and about 6 feet from the side walls.

Close to and parallel to either the front or the side wall there should be a 4-inch feed pipe from which the perforated pipes should extend. From this feed pipe a 4-inch connection should extend outside of the building, terminating in a 3-inch Siamese fire department connection fitted with proper check valves. Through one Siamese connection no more than 400 feet of perforated pipe can be properly supplied, and this should be so divided that no single line should be more than 100 feet long. Systems containing more than 400 feet of pipe must be fed through two or more outside connections.

The equipments for cellars and subcellars must be entirely separate. The outside connection to the cellar must be 6 inches or more above that to the subcellar, and each connection must be marked plainly in raised letters on an iron plate fastened near it

TO PERFORATED PIPES IN CELLAR
TO PERFORATED PIPES IN SUBCELLAR

In order to avoid friction loss there should be as few bends as possible and those curves which are unavoidable should have a radius at least six times the diameter of the pipe.

WIRE GLASS

Early Methods of Manufacture. For many centuries efforts were made to produce a malleable glass, but these efforts have today practically ceased on account of the invention and improvements in the manufacture of what is known as "wire glass." In 1855 there was granted in England, to Alfred Vincent Newman, a patent for sheet glass which was reinforced by a wire netting in the center. It was never manufactured to any extent either by Newman or by the dozen or more other inventors who obtained patents, the physical problem of successfully inserting the wire mesh in the glass having proved for many years an unsolvable problem, at least commercially.

Shuman's One Pour Process. In 1892 Frank Shuman was granted United States patents 483,020 and 483,021 for an improved method of inserting the wire in glass. These patents to Shuman were the first issued in the United States for wire glass, and he was the first person to manufacture it commercially. His process differed from those of any of his predecessors, the early method having been to pour two ladles of glass and imbed the wire in the center, while Shuman used only one pour. In brief, the Shuman process consisted in pouring a mass of glass upon a table where it was acted upon by three rollers which were united. The first roller pressed down and flattened out the mass of glass; the second roller, which was corrugated, pressed into the upper surface of the glass the wire mesh which ran between the first and second rollers; the third roller followed and flattened out and smoothed over the whole surface. Shuman received on November 1, 1893, in recognition of his process the John Scott legacy and premium medal from the Franklin Institute in Philadelphia. It has been stated that Shuman patents are one of the few instances where a patented process was capable of performing its work on a commercial basis when first put upon the market.

The success of Shuman led to many attempts to improve and perfect, and in many cases, doubtless, to infringe upon his patent. There were objections to the Shuman process, namely, the uneven placing of the wire, the hardness of the product, the smallness of the sheets, and fourth, the markings on the glass by the mesh, by which it became known as caramel glass.

Modern "Two Pour" Methods. The manufacturers reached the conclusion that the objections could not be overcome by the "one pour" process, as it was called, and turned their attention to the "two pour" process, which was the first process patented. Leon Appert, in France, and Edmund T. Schmertz, in America, apparently about the same time reached a solution of the latter process, Appert receiving a patent in France, January 24, 1894, and Schmertz applying for one in the United States, March 10, 1895. Litigation immediately arose between the two parties and it was not until May 30, 1905, that the original and reissued patents were granted to the assignees of Schmertz, it having taken something over ten years to settle the controversy between the two contestants. The Schmertz process is the one which is now used most extensively, having superceded both the Shuman and the Appert methods.

Schmertz Method. In the making of wire glass by the Schmertz process a table is provided, over which is passed a leading roller, so placed in relation to the surface that it controls the thickness of the glass. Following this is a chute for feeding the wire netting and another roller, so placed that a second layer of glass is laid upon the first sheet with the wire between. To cast a sheet a sufficient quantity of the melted glass is poured on the table and the first roller moved forward. As soon as this roller has run about 18 inches the wire netting is let down through the chute upon the sheet and made to lie flat upon it. The rear roller then advances and forces the second casting of glass over and through the wire netting, thus firmly welding the glass in the two castings to the wire netting and to each other, into one solid sheet of wire glass, Fig. 140. The product has a polished surface, the wire netting is practically in the center, and the glass is clear. Sheets 150 inches in length are cast without difficulty. The product of this process is capable of sustaining a high polish and this fact has greatly broadened the field of usefulness for wire glass.

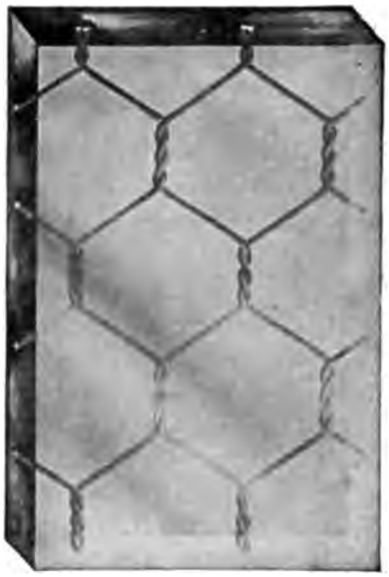


Fig. 140. Sample of Polished Wire Glass
Courtesy Mississippi Wire Glass Company, New York

Shuman's Latest Process. In 1901 Arno and Frank Shuman, the latter the inventor of the first process, invented another method in which a wire netting is placed upon the table, a ladle full of glass is poured upon the netting and the roller passed over it, pressing the glass into a sheet of the desired thickness. This process is said to be used to a limited extent only, as the product made has many of the objections to the first Shuman process. Before 1892, fifteen patents had been issued on wire glass, but since that period over 250 have been granted, and the end is undoubtedly not even in sight. It is perhaps sufficient for this phase of the matter to state that new patents will some time or other be issued which may reduce the value of the first or primary patents and cheapen the product.

Commercial Distribution. Wire glass has been seldom, if ever, ld direct to the consumer, being sold to jobbers in glass and allied terials, as paints, oils, sashes, doors, etc., the requirement being at a jobber must purchase in car load lots and have a warehouse · distributing the glass over his territory. There is some tendency w, however, to get away from the practice of dealing only with the ber and to deal direct with the consumer, especially as the mak-; of the metal frame in which the glass is placed has become a large d important business. Interesting as this part of the wire glass lustry may be, it is not the primary interest in connection with the terial in this work. The student's interest is in the use of wire glass a fire retardant, though some of its other uses are worthy of note.

General Advantages. Wire glass, it should be remembered, does t differ from other glass except in the one particular that if broken any cause, the several pieces hold their position in the sheet tead of falling out. This property can be successfully utilized in ny cases, particularly in skylights where a sacrifice in the amount light can easily be allowed, and in floor and vault lights, where the ment of strength is also necessary. In all such cases wire glass uld have the preference over the ordinary glass, as this would viate the danger of the glass falling when broken and injuring rsons, and perhaps making the property owners liable for dam-es. Another advantage comes from the fact that wire glass can not cut as readily as ordinary glass and hence may more successfully sist the efforts of the burglar to enter through the window.

Value as a Fire Retardant. In fire insurance, however, the chief laim for wire glass is that it resists fire. This discovery was acci-ental, it having been noticed by someone that wire glass had suc-essfully stood up against a very severe fire. This opened for the roduct an enormous field which has been developed to its fullest xtent. There are many places where it is neither possible nor desir-ble to secure an effective fire stop by means of such dense materials s brick or terra cotta, or by some form of translucent partition. This need wire glass immediately fills. It may be a barrier or a stop or fire and at the same time may permit light to pass through. In loor openings it has come to have a very large use, and in conditions f exposure fires, where shutters are not desirable or can not be placed, it is coming to play a very large part. Indeed, hardly a single modern fireproof building is being erected at the present time without having the exposed side protected by metal sash and wire glass. Many elevators which formerly had merely open grill doors are now successfully backed up with the wire glass, thus making more effective the closing of the floor opening. It may be safely stated that a large part of the commercial success of wire glass has been due to the fact that it is such an excellent fire retardant.

Summary. *Advantages.* The specific advantages of wire glass windows from a fire standpoint may be set forth as follows:

(1) The wire glass window can be used on all classes of buildings and on all sides, even the street fronts. The ordinary shutter can not thus be used.
(2) The wire glass window is generally closed at the time of the fire; if open it can be easily and quickly closed. It is the regular window and being opened and closed every day it is known whether it is in order or not. It differs from the shutter in this respect.
(3) A device like the shutter is intended to be used for fire purposes only and will not receive the care and attention which a window used every day will receive.
(4) Wire glass is at its worst translucent and some of it is as transparent as ordinary glass, Fig. 140. It will not permit a fire to burn inside of a building for hours without being seen from the outside.

These four points are considered the leading factors in favor of wire glass.

Disadvantages. Its weaknesses may be thus set forth: a, That the glass will yield from an internal fire if it be sufficiently severe, but this is probably equally true of other fire retarding materials and is not especially to be charged against wire glass. In the case of local exposures where the exposed building may be higher than the adjoining building where the fire is, or where it may be situated across a narrow alley, wire glass has given a most excellent account of itself. In connection with the exposure across the alley which generally will not be less than ten feet and more likely fifteen or twenty wide, it should be borne in mind that the air current is of some value to the resistance and wire glass has certainly stood up well in such cases. It is claimed by many students of the business that wire glass installed in all the windows in metal frames in a city, will eliminate the conflagration hazard. The statement is probably not too strong.

Radiation from Hot Wire Glass. It should be pointed out in conclusion that the matter of radiation of heat from a hot pane of wire glass is a factor to be taken into consideration. For this reason it is a generally accepted rule that stocks should not be nearer than three feet to the windows where there is danger of an exposure fire. The window will stand up under the fire itself without yielding, but it will radiate a sufficient amount of heat to set goods on fire or to damage them.

Some fires, with their dates, are here given, as illustrating the effective use of this material in actual service.

Armour & Company, Chicago, March 27, 1899. Four-story brick building of large area, occupied as Felt Works, totally destroyed except walls. Very quick and severe fire. "Wire glass" windows in wall of Felt Works against a two-story glue storehouse with 10 foot alley between. Exposed unprotected windows in glue storehouse. The "wire glass" windows in wall of burned building protected the other building, which would probably otherwise have been destroyed. A stable 6 feet distant protected by "wire glass" windows was also saved.

This was probably the first important practical test of "wire glass" windows, and was unusually severe because of the fact that the windows were in the wall of the risk which burned.

Armour & Company, Chicago, May 16, 1902. Fire destroyed two sections of Lard Refinery, 100×400 feet, 5 stories in height. A very quick and severe fire. This building had "wire glass" windows which remained more or less intact, except where portions of the wall fell, and aided in preventing fire from spreading to the cannery, 30 feet to the North, and Lipton & Co.'s packing plant, 75 feet distant. Another example of "wire glass" submitted to very severe test from internal fire.

Thos. Roberts & Co., Philadelphia, July 2, 1902. Wool and Cotton Warehouse destroyed. Buildings across alley equipped with "wire glass," which prevented exposure fire from entering.

J. I. Case Plow Works, Racine, Wis., February 24, 1903. Buildings were 13 feet apart. One building was equipped with "wire glass" windows, and these were subjected to a severe fire test of about two hours' duration and prevented fire from spreading to this building.

The Lee Hardware Co., Salina, Kan., December 4, 1903. Lee Mercantile Co.'s five-story brick building 50×250 feet, destroyed. This was 38 feet north of building which was equipped with "wire glass." It is stated that the windows were subjected to a severe test for at least two hours and remained intact, thus saving the property.

Baltimore Conflagration, February 7, 1904. The most notable example of "wire glass" was the new Transformer Station of the United Electric Light & Power Co. This was on the edge of the burned district, fire destroying all buildings except at rear. The street front was protected by large "wire glass" windows which remained intact except one on the lower floor, evidently destroyed by falling wall. While these windows were apparently not subjected to a very severe test, they nevertheless saved the contents of this substation from being damaged.

Another example was the bank building of Alexander Brown & Sons. This stood directly in the path of the conflagration and buildings were destroyed all around it. The south wall was equipped with "wire glass" windows which remained intact, except where broken by falling walls.

Horner Building, New York City, March 25, 1904. Six-story brick building, wood floors, occupied as furniture warehouse; completely gutted by fire with the exception of elevator shaft. This shaft was protected by metal covered doors glazed over about one-half their surface with "wire glass." These doors and "wire glass" remained intact and there was no damage in the elevator shaft.

Powers Mercantile Bldg., Minneapolis, December, 1904. Rear of this building was protected with "wire glass;" 10 feet across alley was Boutell Brothers' brick mercantile building, which was totally destroyed by fire. The "wire glass" windows remained intact and doubtless saved the Powers mercantile building.

Montgomery Ward & Co., Chicago, 1904. Large, five-story brick, mercantile building; mostly clothing; practically a total loss. About 20 to 25 feet across alley was the twelve-story Montgomery Ward Building, protected on exposed side by "wire glass" windows. These windows held intact against this severe exposure with practically no loss to the Montgomery Ward Building.

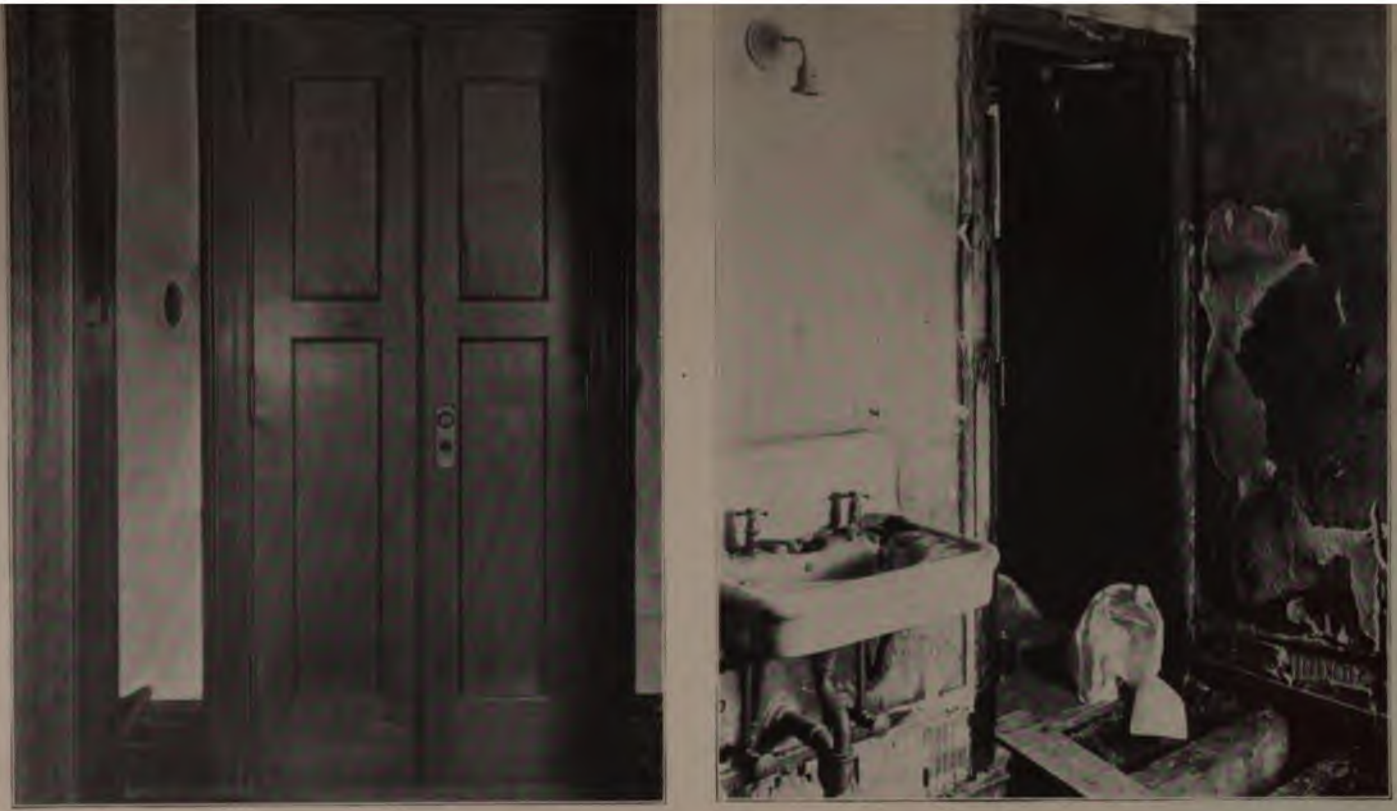
Empire Plow Works, Cleveland, O., October, 1905. "Wire glass" windows in one section of building over the roof of adjoining section. Fire spread from one section to the other through door openings, and these windows were attacked from both sides. The frames were of wood, covered with tin, and very defective. The frames failed and the glass melted.

New York City, December 10, 1905. Two ten-story loft buildings of about equal area, separated by light court about 10 feet wide. One building protected by "wire glass" on light court, while the other building was not protected. The two top stories of the unprotected, or old building, were burned out, subjecting the "wire glass" windows on the new building to a moderate test. The "wire glass" all held intact with little damage.

San Francisco Conflagration, April, 1906. Most notable example of "wire glass" protection was the Western Electric Company's building, which was saved, although everything else in the vicinity was destroyed. This was a four-story brick building with "wire glass" windows on all sides. The area of the glass windows was large and the test a very severe one, particularly on one side. It was equipped with sprinklers, but the heat inside was not sufficient to operate them. The most severe local exposure was a four-story frame lodging house 35 feet distant, and a large pile of some 40,000 wood cross-arms, all of which were totally destroyed. Employes fought the fire from the inside with water pails, extinguishing incipient fires which were started by the intense heat.

Reed Brothers & Co., Cleveland, O., September 25, 1906. Seven-story building, Fig. 111, occupied as a millinery store. Side wall protected with "wire glass" windows, which were more than half the wall area. Twenty feet across alley was the warehouse of the Pittsburgh Plate Glass Co., which was totally destroyed. The "wire glass" windows remained intact except for those windows which were broken by a falling wall. This was apparently a very severe test, as shown by iron fire escape warped by the heat.

Regina Trading Co., Regina, Saskatchewan, Can., June, 1907. Four-story brick hotel burned; 20 feet across was a brick mercantile block and



METALLIC VS. WOOD INTERIOR FINISH IN FIREPROOF CONSTRUCTION
Metallic Door Provided with Wire Glass Panes and the Door Opening on the Right Are Only Fifteen Feet from Each Other.
The Extent of the Damage in the Two Cases Illustrates the Efficacy of Metal Doors and Trim
Courtesy Dahlstrom Metallic Door Company, Jamestown, New York

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ASTOR, LENOX AND
TILDEN FOUNDATIONS

ent store with "wire glass" windows on exposed side. "Wire glass"
act and prevented fire from damaging this block.

icago Sporting Goods Co., Chicago, January 20, 1908. Two brick build-
e to seven stories high, separated by 9 foot alley, windows facing. The

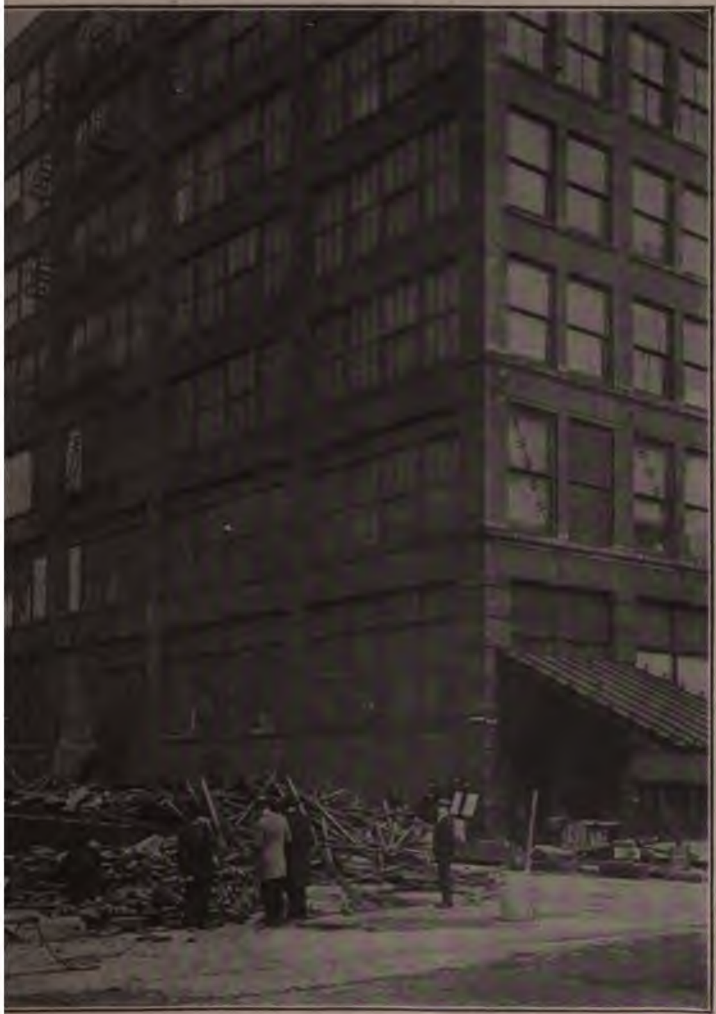


Fig. 141. Illustration of the Efficacy of Wire Glass Protection
Courtesy Mississippi Wire Glass Company, New York

Goods Co. building was gutted by fire, subjecting the "wire glass"
in the building across alley to a severe test. The windows remained
d doubtless saved the exposed building from serious loss.

New York City, March 10, 1908. Six-story brick building, occupied for clothing manufacturing, was practically a total loss. A twelve-story fireproof building adjoining, with "wire glass" windows in wall over the burned building, which prevented fire from entering on that side. No protection on street windows, and fire entered and burned out some of the upper floors. Floor openings in this building protected by terra cotta partitions, stamped metal doors with "wire glass" panels. Some of these doors and glass failed, due partly, at least, to faulty construction, but they prevented the fire spreading from one floor to another through the floor openings.

Atlanta Box Co., Atlanta, Ga., July 13, 1908. Three-story brick furniture factory with "wire glass" windows above the large adjoining and communicating one-story frame box factory. Many of these windows failed and automatic sprinklers in the furniture factory prevented fire from gaining a foothold inside.

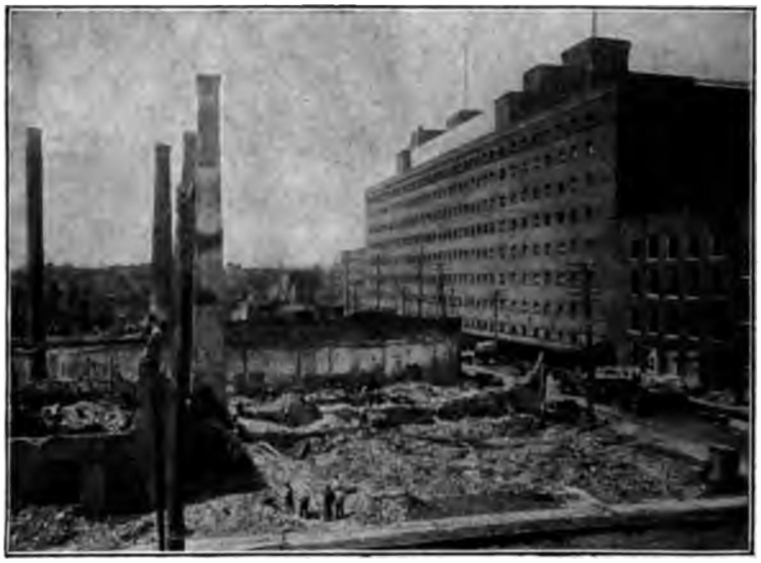


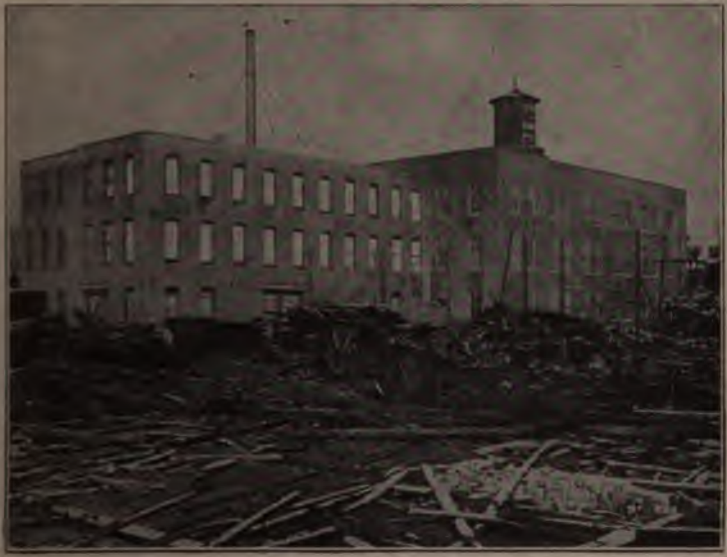
Fig. 142. Striking Example of the Fact That Wire Glass Windows Do Protect. View Shows Butler Brothers Warehouse Uninjured by Fire across the Street
Courtesy Mississippi Wire Glass Company, New York

This must have been a particularly quick, hot fire. The window frame and sash were defective, and it is probable that had the windows been of standard construction the results would have been different.

Cleveland, O., November 15, 1908. Five-story brick mercantile building (clothing stock) destroyed by fire. Adjoined a twelve-story fireproof building with "wire glass" windows in wall above exposure. These windows were given a severe test but held intact. Window shades and frame trimmings inside were scorched in a few cases, but apparently did not ignite.

Frankford, Pa., June 24, 1909. Three-story reinforced concrete building used for drying glue. "Wire glass" windows on two upper floors against one-story frame boiler house and grease extracting building adjoining. The "wire lass" was melted in some cases and everything combustible in building was estroyed but building itself not seriously damaged. The adjoining building pened into the concrete building on first floor without cut-off, and it is probble that "wire glass" was subjected to heat from both sides.

May, Stern & Co., St. Louis, Mo., January, 1910. M. Kahn Glass Co. uilding. Across the alley, about 15 feet wide, was the house furnishing wareouse of May, Stern & Co. The Kahn building was entirely destroyed, with ractically no damage to the Stern building, which latter was protected on the lley side by "wire glass" windows—a very severe and highly successful test.



ig. 143. Effect of Neighborhood Fire on Two Factories, One without, the Other with Wire Glass Protection

Courtesy Mississippi Wire Glass Company, New York

Butler Brothers, Jersey City, August 17, 1910. Block across street consting of baking powder factory, chemical works, work factory, etc., practically total loss, Fig. 142. The exposed windows on Butler Brothers' large fireproof arehouse were equipped with "wire glass," which remained intact and preented fire from entering. Some of the windows were open, but the fusible links leased and the windows closed automatically. The four-story brick buildg adjoining Butler Brothers, also across street from fire and occupied by the iegel Sack Co., was not protected by "wire glass" windows. All of the winows burned out. This building was equipped with sprinklers, and a large umber of the sprinklers near the windows opened and prevented the destrucon of the building, but a serious loss to contents resulted.

Staudte & Rueckoldt Manufacturing Co., St. Louis, Mo., December, 1910. wo three-story factory buildings, subjected on one side to very severe exposre fire from large lumber yard and sheds 10 feet and more distant, Fig. 143.

One of these buildings was equipped with "wire glass" on the side against exposure while the other was not. The "wire glass" held intact and very slight damage in the former, while in the latter the windows burned out and serious internal loss. Both buildings were sprinklered; four heads opened in the building protected with "wire glass" and 117 in the other building.

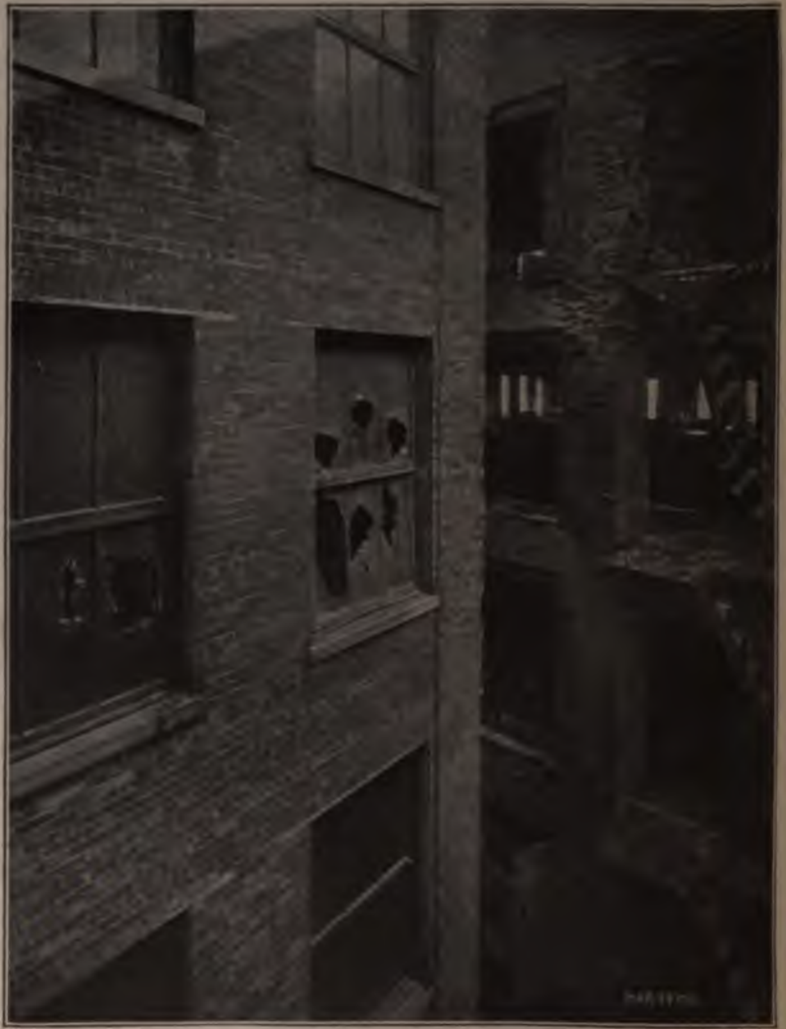


Fig. 144. — Wire Glass Windows Protected This Building Adjoining the Asch Building During a Serious Fire. Holes Made by Fireman's Hose
Courtesy Mississippi Wire Glass Company, New York

Asch Building, New York City, March 25, 1911. Three upper floors of ten-story fireproof building were completely burned out with a terrible loss of life. Across the light court was another fireproof building having exposed windows from 12 to 25 feet distant, protected by "wire glass" windows. These windows were subjected to intense heat, but in all cases remained intact except on one floor where holes were punched through by the firemen to enable them to play hose streams in the burning building, Fig. 144. The iron shutters on the burned building were badly wrecked, and also iron shutters on exposed building to the north and west were badly warped out of shape. There was "wire glass" in the elevator shafts and in the kalamein doors to same. On account of the kalamein construction and the stops pulling away the "wire glass" fell out, but where the frames held properly, the "wire glass" remained intact. On the side of elevator well were large lights about 32×44 feet, well set in metal frames. These all remained intact.

FIRE PAILS

A pail of water or sand is the simplest, and, if used promptly, the most efficient fire extinguishing device. Its use is understood by every one, and because of this fact, as well as the inexpensiveness of the equipment, it is appreciated by the majority of property owners and the insurance people and is, therefore, the most frequently found provision for fire protection. Their usefulness depends upon their being instantly available, and to insure this they should be refilled weekly and regularly inspected. The pails themselves should be conspicuous and should be placed at frequent intervals in conspicuous places.

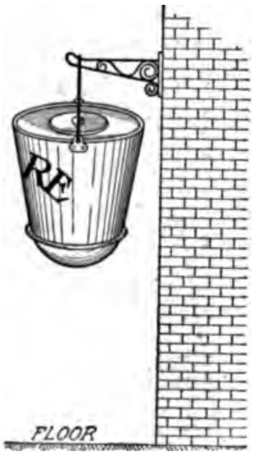


Fig. 145. Fire Pail Suspended on Bracket

Experience and common sense have combined in formulating standard requirements for fire pails and, when these are carefully carried out, insurance companies allow the insured a liberal reduction in their rates. To secure such reduction, however, all parts of the premises used for business purposes must be equipped, including basements and attics, and every floor or part of a floor, such as balconies and mezzanines. In order that any tenant of a non-fireproof building may receive this allowance, all the tenants in the building must be provided with fire pails, while in a fireproof building each floor or, if the floor is divided by fireproof partitions, each section of the floor is considered separately, and only the tenants of that division need be equipped with fire pails for any one of them to secure the allowance.

Specifications. The pail itself, Fig. 145, should have a capacity of from 10 to 12 gallons; should be of galvanized iron—never of wood; and should preferably have a round bottom so that employes can not use it for ordinary purposes and thus have it out of place in an emergency. It should be painted red and marked in black letters at least 2½ inches high:

FIRE or FOR FIRE ONLY

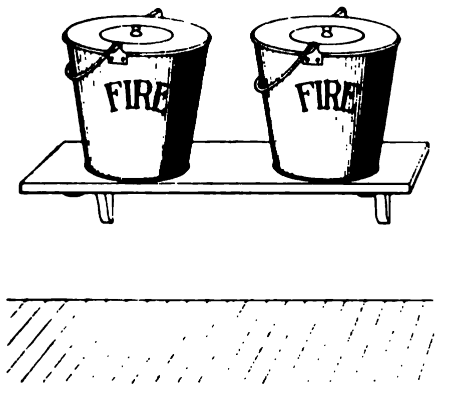


Fig. 146. Fire Pails Located on Shelf

Distribution and Location. A floor space of 1,000 square feet requires for its proper protection two pails, and for each additional 500 square feet or fraction thereof one more pail should be provided. The number of pails required should be divided into groups of from two to six pails each and these groups carefully located so as to be nearest the vulnerable points, especially dangerous places being provided with extra pails. These pails should be placed so that they will be constantly in sight and they should never be covered by stock or rubbish nor should the access to them ever be obstructed by machinery, stock, or accumulations of packing waste, etc. They are best located near elevators, exits, stairways, etc., and the separate groups should be staggered or criss-crossed over an area.

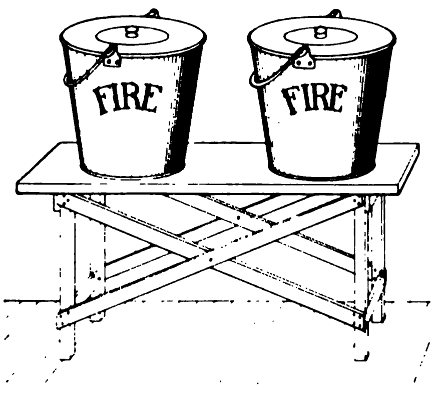


Fig. 147. Fire Pails on Floor Stand

The pails should be placed on brackets, shelves, or benches especially provided for the purpose, Figs. 145, 146, and 147, that the top of the pail will not be more than 5 feet nor the bottom of the pail less than 2 feet from the floor.

Insurance companies do not approve of equipments in which the pails are set on work tables, benches, window sills, stock shelves, or in any other place not originally intended for that purpose.

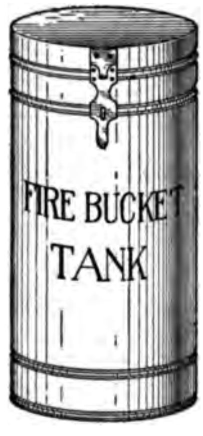


Fig. 148. Patent Fire Bucket Tank

Filling and Maintaining Pails. Each pail should be refilled once a week with clean water, and may or may not be provided with a cover to prevent accumulations of dust and dirt on the top. Wherever fires from oils and paints and other inflammable liquids are apt to occur, a half of the required number of pails should be kept about two-thirds full of clean, dry sand and should be provided with a scoop for throwing it. (If sand pails are kept full, they will be too heavy to be easily and quickly handled.) Sand smothers gasoline or other oil fires, whereas water simply floats the burning liquid about.

The care of fire pails should be given to some competent person—such as the foreman, janitor, or engineer—who should be held responsible for their condition.

Substitutes. Chemical extinguishers, bucket tanks, or casks may replace a part of the pails on any floor although half of the pails must remain. One three-gallon approved chemical extinguisher is considered the equivalent of six pails, or of one cask and three pails. Patent bucket tanks contain six buckets stacked within each other and immersed in a chemical, as shown in Figs. 148 and 149. These are so arranged that when the cover is removed from the tank, the bale of the first pail springs up; as this is removed the bale of the next lower one comes up; and so on. One

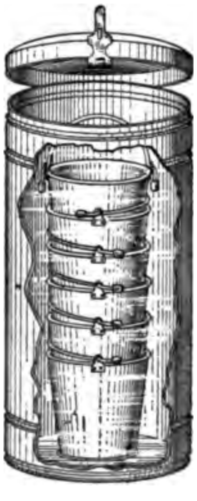


Fig. 149. Part Section Showing Construction and Arrangement of Fire Bucket Tank

of these tanks may replace six pails provided the tank is inspected weekly to see that the pails can be be readily withdrawn.

Casks of water will be accepted as the equivalent of six pails, provided the cask meets the following requirements:

> The cask to be of oak, painted red, with FIRE or FOR FIRE ONLY in black letters 6 inches high or more; its capacity to be at least 50 gallons; the cask to be provided with a cover having a handle; and to be always accompanied by three standard fire pails on a shelf or on hooks near by, Fig. 150.

Freezing. If fire pails are located where they are apt to be frozen in winter, two pounds of chloride of calcium or of common salt should be thoroughly dissolved in each pail to keep it free from ice. A cask requires 50 pounds of the chloride of calcium, or salt.

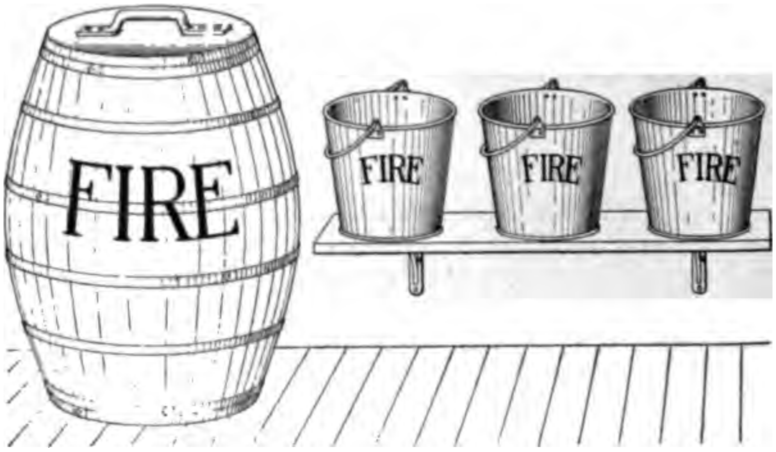


Fig. 150 Standard Equipment of Fire Barrel and Pails

CHEMICAL EXTINGUISHERS

Few Satisfactory Types. Quick to take advantage of the universal fear of fire, numerous manufacturers have put upon the market various forms of so-called chemical fire extinguishers purported to have marvelous extinguishing properties. When tested at the Underwriters' Laboratories, however, these chemical solutions or powders, with but two exceptions, have proven to be of no practical value. These exceptions are the carbonic acid gas extinguisher and the "Pyrene" extinguisher, both liquids. All forms of dry powder extinguishers are, because of their physical properties, evidently inferior. Their installation is not recommended, as attempts to extinguish fires with them cause delay in using water or some other more efficient agent. For fighting fires where water would do damage, a satisfactory mixture may be made of bi-carbonate of soda and iron ore, commonly known as red or yellow ochre, in the proportion of one pound of ochre thoroughly mixed with nine pounds of soda. Such powder should be kept dry in covered metal cans.

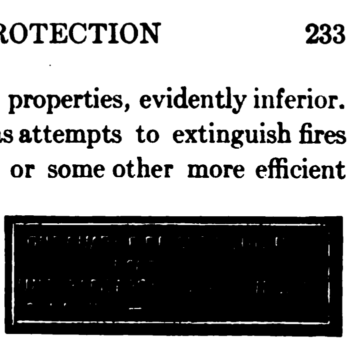


Fig. 151. Underwriters' Laboratories Label for One Quart Extinguisher

Inspectors from the Underwriters' Laboratories examine approved types of extinguishers at the factories where they are made. Those extinguishers which satisfactorily meet the requirements may bear the proper Underwriters' Laboratories Label, Figs. 151, 152, and 153.

Fig' 152. Underwriters' Laboratories Label for Two and One-half Gallon Extinguisher

Carbonic Acid Gas Extinguishers. The form of chemical fire extinguisher in most general use at present is the carbonic acid gas variety, there being more than twenty firms manufacturing such extinguishers whose products are approved by the National Board of Fire Underwriters. These extinguishers, although effective on fires where water would be effective, are of no special value in subduing fires among oils or other volatile liquids, nor are they safe for use

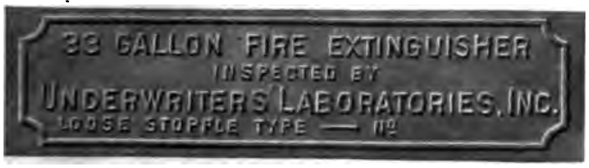


Fig. 153. Underwriters' Laboratories Label for 33 Gallon Extinguisher

on electric arcs or machinery carrying high voltages because of the conductivity of the water.

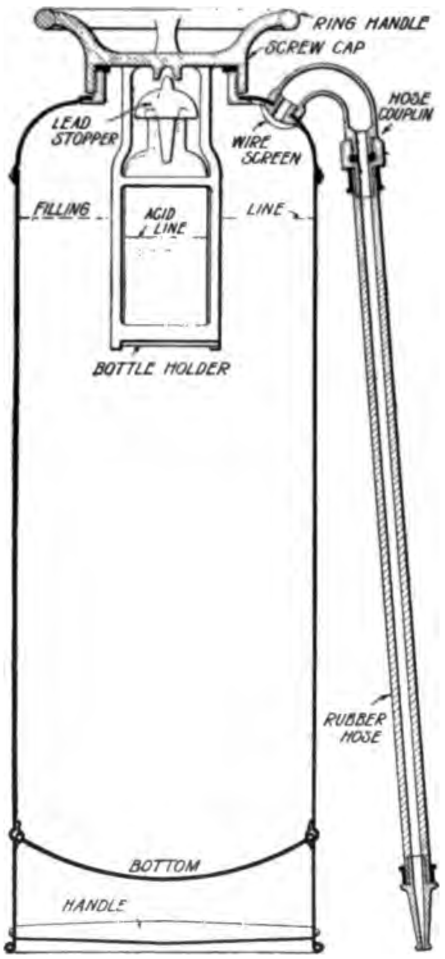


Fig. 154. Section of Babcock Hand Extinguisher Showing Method of Operating

Construction and Method of Operation. This type of extinguisher consists mainly of a rubber hose, Fig. 154, attached to a closed metal tank which is partly filled with a solution of bi-carbonate of soda. Held upright in a cage built in the top of the tank is a bottle which is closed by a loose fitting lead stopper, and which contains sulphuric acid. To operate the extinguisher, the tank is turned bottom upwards and in this position the loose stopper drops out against the top of the cage and allows the sulphuric acid to escape gradually. The acid mixes with the soda solution and the resulting chemical action generates carbonic gas, which in turn produces great pressure and forces the charged water out through the hose. Since carbonic acid gas itself is not a supporter of combustion, it adds to the extinguishing value of the water, as do also the sodium salts which the water holds in solution.

As chemical fire extinguishers are most often used by inexperienced persons, it is of utmost importance that their operation be simple, such as turning them upside down; that they be entirely safe, *i.e.*, that every part be sufficiently strong to withstand the pressure generated with a large

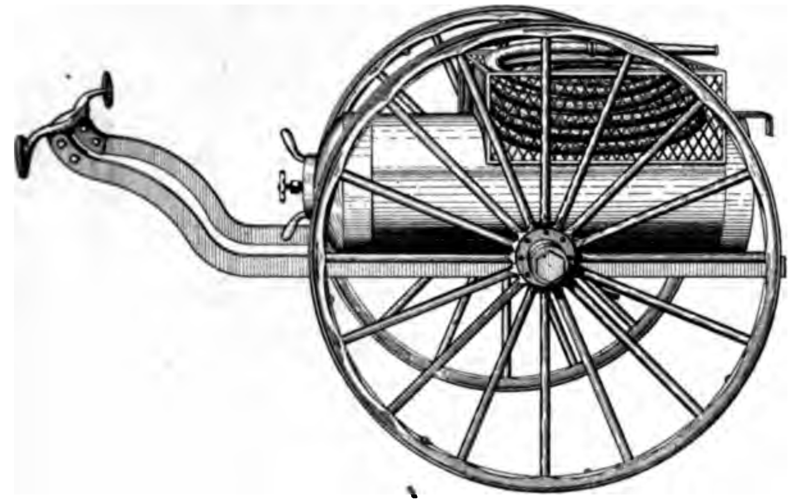


Fig. 155. Large Capacity Chemical Extinguisher on Wheels with Hose Cage

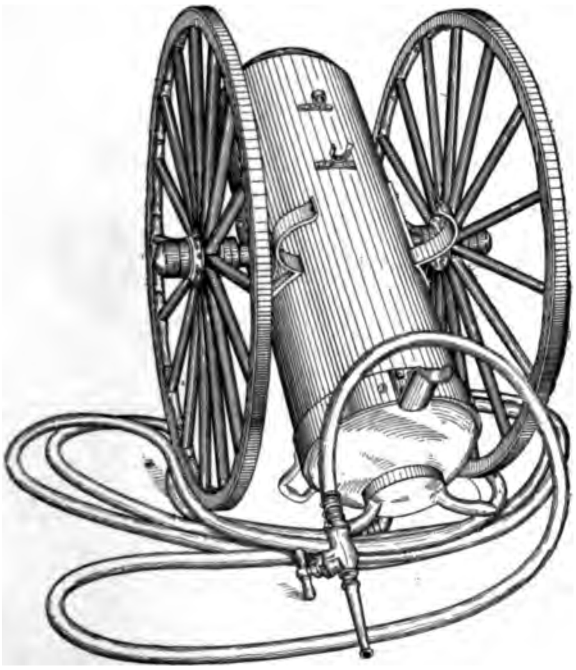


Fig. 156. Large Capacity Chemical Extinguisher on Wheels

margin of safety; that they be protected against the weakening effects of corrosion; and that the acid be fed evenly and slowly so that sudden excessive pressures will not be produced.

These carbonic acid gas extinguishers are built in several sizes. The largest size is mounted on wheels and is designed as a chemical engine for fire department use. Smaller sizes, Figs. 155 and 156, mounted on wheels are for private use on the owner's property. There is also a stationary type, Fig, 157, and the small portable hand extinguisher.

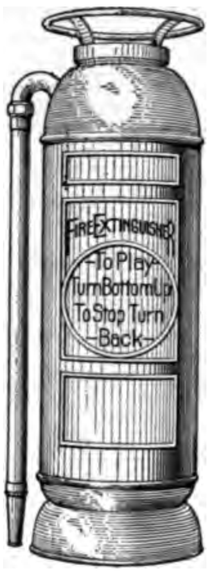


Fig. 157. Stationary Chemical Extinguisher

Underwriters' Requirements. The National Board of Fire Underwriters issue an outline of specifications for the construction and installation of chemical fire extinguishers for other than fire department use. Extinguishers fulfilling only their requirements may yet have features making them unsatisfactory, while other extinguishers departing in some details from these requirements may prove satisfactory. The Underwriters' Laboratories give the ultimate decision in any case.

Below are given the requirements for the Hand Chemical Extinguishers which is the variety most extensively used.

CARBONIC ACID GAS HAND FIRE EXTINGUISHERS FOR OTHER THAN FIRE DEPARTMENT USE

(1) Capacity.

Not less than 3 gallons nor more than 3 gallons 4 ounces to lower edge of collar, and not less than 2½ gallons nor more than 2½ gallons 4 ounces to the filling indicator.

(2) Shell.

(*a*) Cylinder not less than No. 18 B. & S. gauge, hard copper, dome and bottom to show at least No. 17 B. & S. gauge in all parts after spinning.

(*b*) Shell* to be safe against distortion or strain with 350 pounds hydrostatic pressure held for one minute. Each shell to be so tested and so marked before shipment.

(*c*) Openings for cast fittings to fit close and inside of shell to fit close to flanges of fittings.

(*d*) Shell to have stiffening ring at lower edge.

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*Shells which show distortion or strain at 10 per cent or burst at 20 per cent above 350 pounds will not be considered safe.'

(*e*) Filling indicator to be of metal.

(*f*) If used, riveted and beaded seams to be thoroughly sweated, and rivet oles to be accurately punched to meet and avoid buckling of sheet. Both laps f beaded seams to fit each other and be proportioned to be sprung together efore soldering.

3) Collar.

(*a*) Inside diameter not less than 2½ inches in clear.

(*b*) To have sufficient height to prevent cap reaching dome with gasket emoved.

4) Cap.

(*a*) Must screw to collar—threads to be protected against exposure to ontents of extinguisher.

(*b*) A gasket not less than 1/16 inch thick nor less than 5/16 inch wide to be sed at the joint and to fit recess snugly.

(*c*) To have four or five threads holding.

(*d*) To be of hard red brass* and have ample metal back of gasket recess.

(*e*) To have ring form of handle about 6 inches in diameter.†

5) Outlet.

(*a*) Outlet casting to have not less than ¼-inch internal diameter at any oint and not less than 3/32-inch wall.

(*b*) Hose connection to outlet casting to be so designed that hose can be etached and replaced without liability of injury to hose or obstruction of tream.

(*c*) To be located midway between center of top handle and center of abels. Distance between ring casting and outer surface of outlet casting to e not more than one inch.

(*d*) Outlet to be screened with brass netting or perforated plate, heavily oated.

6) Coating.

(*a*) Shell, collar, cap, outlet, and hose coupling, except threaded suraces, to be heavily, evenly, and completely coated on inside at factory with lloy of tin and lead.

(*b*) Joints and rivets, if any, to be covered to form a smooth interior urface.

7) Handles.

(*a*) Ring form of handle to be used on cap. See 4 *e*.

(*b*) Bottom handle to allow not less than 1½ inches free clearance for and, and side handle not less than 3½ inches free clearance in width.

(*c*) Bottom handle to be parallel with top handle, not to rely entirely n solder as a fastening, and to be rigid, not hinged.

(*d*) Top handle to be diametrically opposite direction plates, securely veted and soldered to shell, not extending through it. It should preferably e cast, formed to fit the contour of the shell where it is riveted, and strong nough to allow a lever to be used between it and the ring on the cap in case e cap is tightly stuck.

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*A composition of about 83 per cent copper, 7 per cent tin, 7 per cent zinc, and 3 per ent lead is desirable.

†Castings to allow one inch clearance between upper surface of cap and lower surface ring, and to have the finished cap when coated, but without cage attached, weigh about o pounds.

(8) Cage.

(*a*) To support bottle at bottom and be arranged to allow ready removal and replacement of bottle without danger of dropping bottle or spilling acid.

(*b*) Not to rely on solder entirely for fastening parts. All joints and connections to be mechanically secure without solder and then soldered for protection against corrosion and the whole cage heavily coated with alloy of lead and tin.

(*c*) To have no sharp corners or projections which can mar the collar casting as the cage passes through.

(*d*) To fit bottle loosely and hold bottle in place when inverted.

(*e*) Cages depending on movable parts in discharging extinguishers and cages supporting bottle by neck not approved.

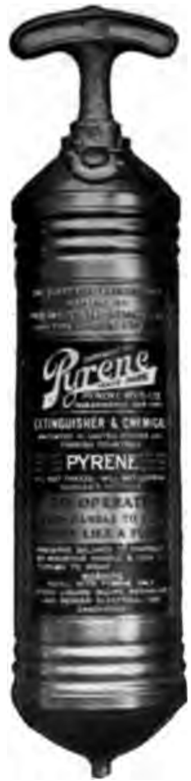

Fig. 158. Pyrene Hand Extinguisher

(9) Bottle.

(*a*) Acid line to be blown in or etched on glass and accurately placed. Ground lines deeply cut increase liability of breakage.

(*b*) (Specifications to be submitted later to insert here, covering bottle best adapted for interchangeability.)

(10) Hose.

(*a*) To be of approved make of three-ply rubber capable of withstanding a hydrostatic pressure of 400 pounds to the square inch held for five minutes.

(*b*) To be so attached to outlet that coupling will withstand a hydrostatic pressure of 350 pounds to the square inch held for one minute.

(*c*) To be attached to hang vertically and so that it can be readily removed and replaced when necessary. (See 5 *b*.)

(*d*) To be of such length that with hose hanging vertically, tip of nozzle will just clear any plane surface on which extinguisher is placed.

(11) Nozzle.

(*a*) To be of material which will not be affected by corrosion.

(*b*) To be cast free from blow holes, checks, or other imperfections; interior to be finished smooth and tapered toward the orifice. Discharge opening to be not less than ⅛ inch nor more than 3/16 inch diameter, preferably drilled straight for about 3/16 inch back from orifice and chamfered.

(12) Chemical Charge.

(*a*) Sulphuric acid and bicarbonate of soda to be in such proportions that a pressure can not be obtained in excess of 325 pounds with soda solution at 120°F. Stream shall not show acid reaction. 1¼ to 1½ pounds bicarbonate of soda and 3½ to 4 fluid ounce sulphuric acid recommended.

(13) Marking.

(*a*) Directions for operating to be plainly and permanently fixed on the side of the shell diametrically opposite the top handle (See 7*d*), and so as o be back of hose. Letters to be not less than ½ inch in height and of a different color than background.

(*b*) Directions for recharging to be plainly and permanently fixed on the side of the shell directly under the directions for operating. These must state

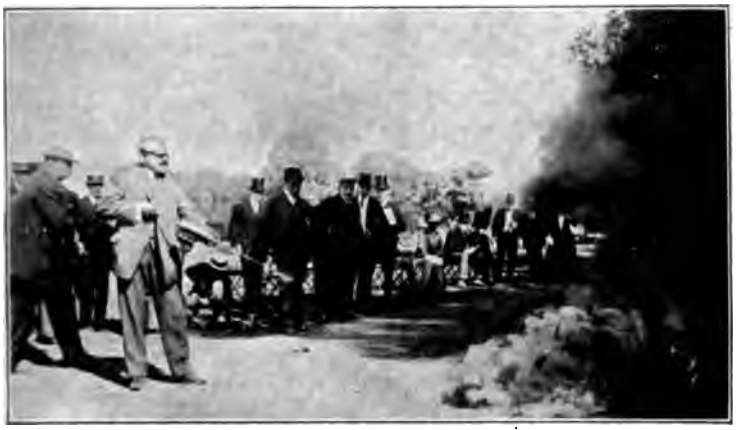

Fig. 159. Pile of Cotton Waste Saturated with Gasoline Extinguished in a Few Seconds with Pyrene Extinguisher

hat the extinguishers, if not used for a fire, must be discharged and recharged t least once a year and record of same kept on card* attached to machine. They must also state that whenever the extinguisher is discharged it must be ntirely emptied and thoroughly cleaned before refilling, and that the extinguisher must be protected from frost.

(*c*) Name and address of manufacturer and trade name of machine must be permanently marked on each extinguisher.

In General.

Extinguisher to be constructed and finished in a thoroughly workmanlike manner; to have as few parts as possible; to be free from moving parts subject to corrosion; and not to be equipped with shut-off valves.

Extinguishers applying the acid slowly are preferred. Under the majority of fire conditions best results will be obtained with feed proportioned to each maximum pressure in about 25 to 35 seconds and not to exhaust liquid n stream under 50 to 65 seconds—solution being at ordinary temperature.

"Pyrene" Extinguishers. The only other type of chemical xtinguisher approved for use by the Underwriters' Laboratories the "Pyrene." This extinguisher consists of a quart of patented tinguishing fluid contained in a double acting metal syringe, Fig. 8. To operate, the handle is given a quarter turn to the left and en worked back and forth to eject the fluid. The contents of these tinguishers is a liquid composed chiefly of *carbon tetrachloride*.

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*Cards to be of linen, sized and attached to upper handle by brass wire or ring or set metal frame soldered to shell.

This does not freeze above −50°F. and it remains a fluid up to about 200°F. at which point it turns into a heavy gas or vapor blanket which covers and smothers the fire.

"Pyrene" extinguishers have been found valuable in extinguishing incipient fires where water or solutions containing large percentages of water are not effective, as in Fig. 159. It is also valuable in extinguishing fires in volatile liquids, calcium carbide, and in all places where the gas from the fluid can be confined about the fire. Furthermore, it is effective in extinguishing electric arcs without danger to the operator, Fig 160.

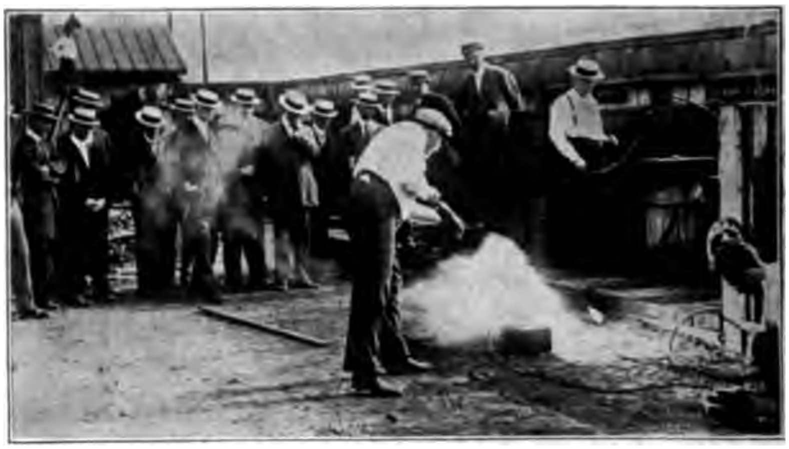

Fig. 160 Dangerous Electric Arc Being Extinguished by the Use of Pyrene Extinguisher

"Pyrene" is not poisonous and it does not damage articles on which it is thrown as does water.

PRIVATE FIRE ALARMS

Private fire alarms are mechanical and telegraphic devices for detecting, or for giving, the alarm of fire. They are of two general classes, manual and automatic.

Manual Fire Alarm. The manual fire alarm, as its name indicates, is operated by hand. It consists ordinarily of a number of signal boxes suitably placed about the building or plant, the signals being operated by turning a crank or pulling a hook. Each signal box contains a transmitter, the wheel of which is provided with

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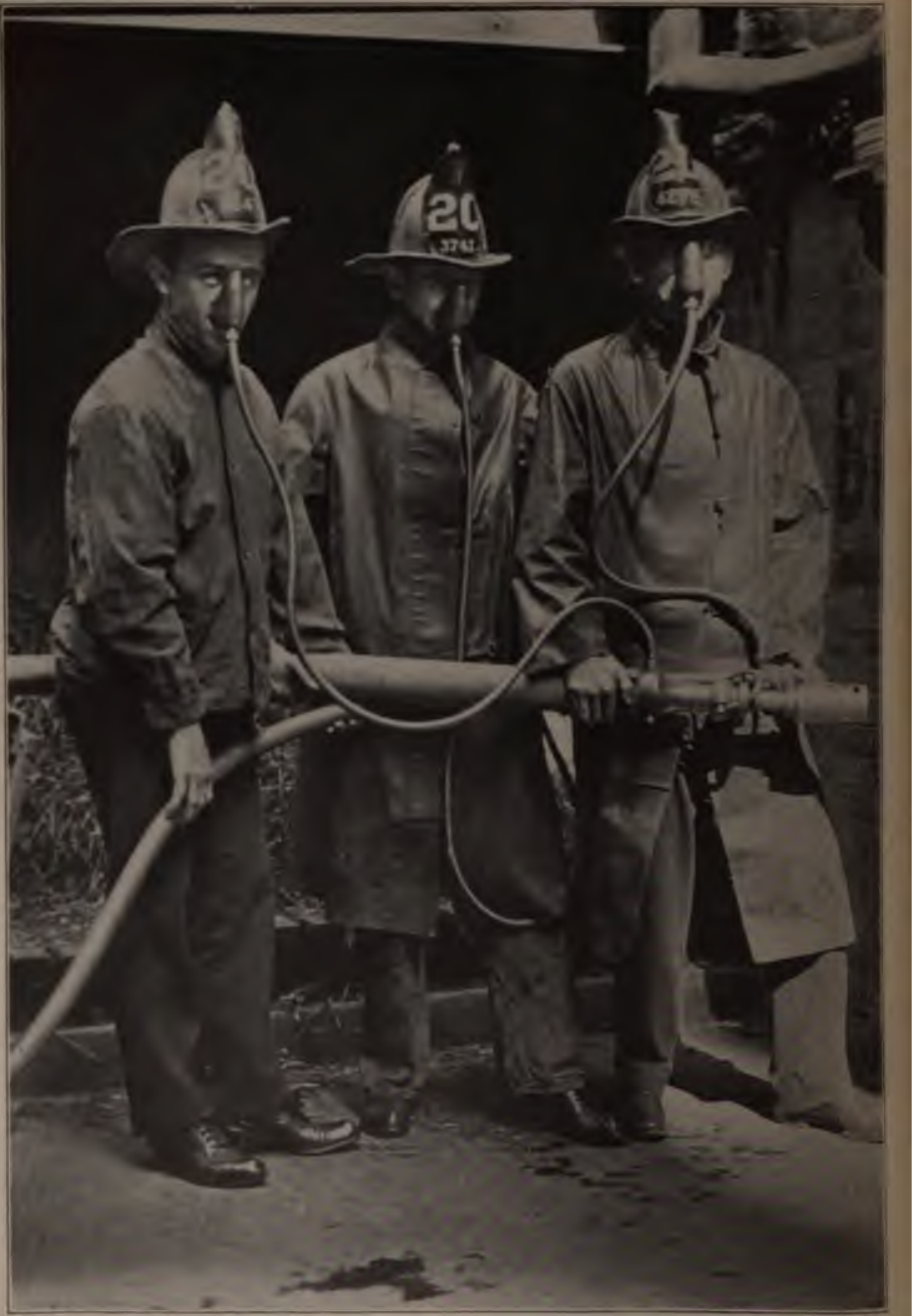


SMOKE-PROOF INVENTION IN USE IN THE NEW YORK CITY FIRE DEPARTMENT
By the Aid of Nose Protector and Separate Hose System, Through Which Fresh Air May Be Pumped to the Firemen, They Are Able to Protect Themselves Against Suffocating Smoke

suitably arranged teeth; when the wheel is turned it closes an electric circuit, which transmits an alarm at the central station.

Automatic Fire Alarm. The automatic fire alarm consists of the ordinary fire alarm telegraph apparatus which is set in operation by a fire detector, called a *thermostat,* a name first applied by Dr. Ure to an instrument patented by him in 1831. The thermostat is a device for closing or opening an electric circuit when the surrounding air reaches a certain temperature. The operation of this mechanism is brought about in various ways such as by the expansion of mercury in a thermometer tube; the unequal expansion of the metal in a spring, which consists of two thin strips of dissimilar metal; the straightening of a metal tube by the expansion of ether; and the sagging of a long wire suspended between horizontal supports. Many thermostats designed to operate on a closed circuit have their connection broken by a solder release. Most thermostats are set to operate at 140° to 160°F.

The thermostats which are approved by the National Board of Fire Underwriters at the present time are, in general, small copper tubes filled with air. These tubes which are installed along ceilings or pipings are connected with contact closing and special test devices. When a fire or a dangerously high temperature heats the air in the tube to a certain fixed degree, the air expands sufficiently to actuate a diaphragm which closes an electric circuit, thus transmitting the alarm.

Board of Underwriters' Rules. The following are the rules and requirements of the National Board of Fire Underwriters for the construction and installation of signaling systems including Manual Fire Alarm Systems, Automatic Alarm Systems and Thermostats, Automatic Journal Alarms, and Automatic Sprinkler Alarms, used for the transmission of signals affecting the fire hazard.

Especial importance is placed upon the methods employed in testing, inspecting, and maintaining signaling systems. Not one of these systems is sufficiently automatic to do away with the necessity for periodical inspections and working tests of all of their parts. Such systems must be under the supervision of a responsible person, satisfactory to the municipal authorities and the Inspection Department having jurisdiction, who shall cause proper tests and inspections to be made at frequent intervals and have general charge of all alterations and additions. Records of such tests and inspections should be kept accessible to the Inspection Department and others interested.

CLASS A—WIRING FOR ALL SYSTEMS

NOTE: For other rules governing wiring for signaling systems which are hazardous only because of their liability to become crossed with electric light, heat or power circuits, reference should be made to Rule No. 64, Signaling Systems, of the "National Electric Code."

(1) **Underground Wires.** To secure the largest measure of safety and efficiency in the operation of signaling systems all wires outside of buildings should be placed underground.

(2) **Aerial Wires.** Where from the nature of the case it is impracticable to place wires underground, the following rules must be observed:

(*a*) Must be equipped at points where they enter buildings with approved heavy current protectors.

(*b*) Must be equivalent in conductivity and tensile strength to No. 14 galvanized iron (12 B. & S.) where single wires are used, and to No. 16 B. & S. hard drawn copper where cables are used.

(*c*) Must have an approved insulating covering.

NOTE: Line wires must have a good weatherproof covering, consisting of a thoroughly saturated and filled braided covering at least $\frac{1}{32}$ inch in thickness. Wires in cables to have same covering as single wires and in addition a substantial filled covering around the several wires. Service wires to building and boxes must have an approved rubber covering. See list of Electrical Fittings.

(*d*) Must, when strung on poles, be supported at least every 150 feet, and as far as possible, run under rather than over electric light or power wires.

Where wires are attached to the outside walls of buildings, they must have an approved rubber insulating covering.

(3) **Wires Inside Building.** (*a*) Must be equivalent in conductivity, and tensile strength to No. 16 B. & S. copper wire where single wires are used, and to No. 18 B. & S. copper wire where cables are used.

NOTE: For the wiring in Central Stations—Section "c" and "f" may be modified as circumstances demand.

(*b*) Must have approved insulating covering.

NOTE: In permanently damp places or where run in conduit a rubber insulation at least $\frac{3}{64}$ of an inch in thickness, constructed in accordance with the National Electrical Code Standard, and covered with a substantial braid will be required. For open work in dry places, a filled braided covering at least $\frac{1}{32}$ inch in thickness will be required. For moulding and tubing, a rubber or filled braided covering at least $\frac{1}{32}$ inch in thickness will be required. Samples of all cables should be submitted before being installed.

(*c*) Unless encased in approved tubing or thoroughly filled moulding must, except as hereinafter provided, be run in plain sight and entirely supported on non-combustible insulators placed not more than 8 feet apart, and so arranged that the insulating covering of the conductors will come in contact with no other substances than the designed supports, the protecting bushings and the correcting instruments.

(*d*) Must be protected from abrasion and from accidental contact with other conductors.

NOTE: Where subject to severe mechanical injury, substantial boxing or iron conduit must be used on side walls, otherwise approved moulding may be used. Wires should be run over rather than under pipes, and their coverings must be separated from contact with all pipes by a solid insulating substance creating a separation of at least ½ inch. Special attention must be paid to the mechanical execution of the work. Careful and neat running, taping of wire, and attaching and securing of fittings are required.

(*e*) Must be installed as far as possible without joints. Where joints are necessary, they must be mechanically and electrically secure, and covered with an insulation equal to that on the conductors.

(*f*) Must, in bay construction, follow contour of ceiling, and not be strung from beam to beam. In joisted construction, unless run parallel with joists, must be placed in moulding or have a 4-inch wide wood backing strip with knobs or cleats fastened to the bottom of this strip.

(*g*) Must, where exposed to mechanical injury, and between batteries, transmitters, testing apparatus, annunciators, bells, etc., be enclosed in boxing, moulding, or approved conduit.

(*h*) Must, when passing through iron, brick, stone, or any damp partition or through any floor, be protected by approved bushings.

NOTE: Glass and porcelain are approved for bushing. Where from the nature of the case, it is impossible to use glass or porcelain, approved flexible tubing may be used. See list of Electrical Fittings.

CLASS B—ENERGY FOR ALL SYSTEMS

(4) **Central Energy.** The following sources of energy are given in their order of preference:

(*a*) *Storage Batteries.* To be in duplicate sets, each set capable of operating the system at full capacity for 60 hours, installation to be in a room provided with suitable ventilation and effectually separated from that containing other fire alarm apparatus.

Cells should be mounted on glass and porcelain supports, secured to metallic frames suitably protected from corrosion, except that when cells too large to be so mounted are used, such cells may be mounted on suitable glass insulators.

At least two reliable independent sources of charging current to be provided. It is preferable that the voltage of the charging circuit be not over 250 volts. Batteries to be protected by approved enclosed fuses in tight metal cabinets at the battery terminals.

NOTE: It is recommended that all copper conductors in battery room be coated with lead—applied directly on the copper.

Suitable provision to be made on a switchboard for charging the batteries, with approved means of protecting them against injury due to interruption of charging current, to reverse charging current, or to excessive rate of charge; also provision for shifting the respective batteries from charging to working and from working to charging without opening any of the working circuits during the process of shifting, and so that charging current can not be accidentally connected to any of the working lines during the process of shifting.

(*b*) *Motor Generators.* A sufficient number of motor generators to be provided to supply all circuits without overloading any machine, and with a reserve capacity equivalent to one-half of the total capacity of the station. Motor generators to be driven from all available independent exterior sources of energy, and also by a special generating plant in the headquarters building, driven by some form of prime mover constantly available for immediate operation.

With either battery or motor generator source of energy, the voltage applied to maintain normal line current on circuits must be such that the line current will not be reduced below safe operating value by the simultaneous action of eight transmitters.

(5) **Local Batteries.** (*a*) Must be located in a place favorable to their operation and maintenance.

(*b*) Must be enclosed to prevent mechanical injury, but be readily accessible for inspection.

CLASS C—CENTRAL STATIONS

Systems operating through an approved Central Station are regarded as superior to local or private systems. Before acceptance is obtained for any equipment operating through a Central Station, the Company must file with the Inspection Department having jurisdiction, a general description of the apparatus it proposes to install, together with such detailed information and drawings as are necessary to the complete understanding of the operation of the system. It must also furnish such daily reports to its customers and the Inspection Department having jurisdiction, as may be required.

NOTE: If the Inspection Department requires it, the operating Company shall also furnish:

First. Diagrams showing the manner in which it proposes to connect the various equipments to its Central Station and deliver signals to the patrol and city department.

Second. A satisfactory guarantee as to its ability to render this service and as to the maintenance and efficiency of its system.

(6) **Headquarters.** (*a*) Must be located in a building provided with fire protection, satisfactory to the Inspection Department having jurisdiction, and be equipped with the necessary instruments of an approved pattern for automatically receiving and recording all signals. The time of the receipt of signals must also be recorded, preferably by an automatic device.

(*b*) Must have at least two competent men on duty constantly, and in addition, maintain a runner service so arranged that any building protected can be reached within 15 minutes.

NOTE: All runner service maintained must be sufficient so that the two operators will always be in attendance, except that only in an extreme case one of the operators may be used as a runner. All runners shall be of mature age, and one such man shall also be in charge of the Central Station.

(*c*) Must have two independent means of transmitting alarms to the fire department.

(7) **Devices, Circuits, Etc.** (*a*) Must be designed and installed so as to successfully meet the most severe conditions obtained in practice and no change or alterations shall be made in same without approval.

(*b*) Must be arranged so that interference of signals will be impossible under any conditions likely to be met in practice.

(*c*) Must automatically register at the Central Station distinctive trouble signals when any part of the wiring system is grounded, broken, or impaired, so as to prevent the normal operation of the system.

(*d*) Must, from the risk to the Central Station, under normal conditions, employ complete metallic circuit for the transmission of signals and depend upon an earth return circuit, if at all, only for transmitting trouble signals, except that where fire signals are transmitted over two independent circuits by the same piece of apparatus, the two circuits may have earth return.

(*e*) Must be arranged to receive, record and transmit to fire department and insurance patrol the box number of the building from which an alarm has been received.

(*f*) A terminal board of slate or marble must be provided. Each side of each entering circuit must be equipped with protectors especially approved for this service.

(*g*) Approved automatic devices to be provided, by means of which openings of circuits will be immediately announced by visual and audible signals. Manual tests of all circuits to be made at least four times during each 24 hours.

In every case facilities must be provided for making the following test: Current strength on each circuit; this current to be adjusted to normal before making the other tests; voltage across terminals of each circuit at the inside terminals of protective devices; voltage between ground and each side of each circuit; and voltage between positive side of each circuit and negative side of all other circuits.

CLASS D—MANUAL FIRE ALARM SYSTEMS

NOTE: Only systems operating through a Central Station are approved.

NOTE: These systems are considered inferior to Central Station Night Watch and Fire Alarm Systems.

(8) **Boxes and Manuals.** (*a*) Must be of approved types; be used for no other purpose; and must be arranged to give a distinctive signal from each box or manual, except that where boxes or manuals are located on the same floor of a fire section, such boxes or manuals may give the same distinctive signal.

NOTE: A box such as is approved for Central Station Night Watch and Fire Alarm Systems, however, may be used if desired.

(*b*) Must be located near all main exits and, in addition, must conform to the following:

1. Must be located so that from any part of the plant equipped not more than 200 feet will have to be traversed in order to reach a box.

2. Must, where buildings are more than one story in height, have a box on the first story, and at least one in alternate stories; *i.e.*, 3d, 5th, 7th, etc. Where buildings have single floor area of 7,500 square feet or over, there shall be at least one box on each floor.

NOTE: If risk has multiple tenant occupancy, Inspection Departments may require additional boxes to those called for above.

3. Must, where any plant or building equipped is divided into sections, have the boxes in each section to agree with above rules, account not being taken of the boxes in any other section.

(*c*) Not over 40 boxes or transmitters shall be permitted on a single circuit.

(9) **Tests.** All boxes to be tested at least monthly, a record of these tests being made.

CLASS E—AUTOMATIC FIRE ALARM SYSTEMS AND THERMOSTATS

NOTE: Only systems operating through a Central Station are approved.

(10) **Circuits and Apparatus.** (*a*) Must be arranged to transmit to Central Station the box number of the building in which a thermostat has operated and, unless floor number is transmitted with alarm, must automatically register the floor number on an annunciator located as required by the Inspection Department having jurisdiction.

(*b*) Must be so arranged that not more than fifteen building equipments will be connected on a single circuit unless the circuit is mainly underground, in which case the number of equipments shall not exceed twenty-five (25), except by special permission of the Inspection Department having jurisdiction.

(*c*) Transmitters, manual alarm boxes, testing boxes, and annunciators must be of an approved make, and so located that a considerable jar can not start their mechanism.

(11) **Installation of Thermostats.** (*a*) Must be placed throughout premises, including inside of all closets, in basements, lofts, elevator wells and under stairs. Special instructions must be obtained relative to placing them under large shelves, decks, benches, tables, overhead storage racks and platforms, and inside small enclosures, such as drying and heating boxes, caul boxes, tenter and dry room enclosures, chutes and cupboards. No portion of the premises shall be excepted without written consent.

NOTE: Special instructions must be obtained from the Inspection Departments having jurisdiction as to the location of high test thermostats in boiler rooms, heating boxes, skylights, etc.

(*b*) The distance from wall or partition not to exceed one-half the distance between thermostats in the same direction.

(*c*) A line of thermostats to be run on each side of partition. This rule applies to both solid and slatted partitions.

(*d*) Under mill ceilings (smooth solid plank and timber construction, 6 to 12 feet bays) one line of thermostats should be placed in center of each bay and distance between the thermostats on each line not to exceed the following: 8 feet in 12 feet bays; 9 feet in 11 feet bays; 10 feet in 10 feet bays; 11 feet in 9 feet bays; 12 feet in 6 to 8 feet bays.

Measurements to be taken from center to center of timbers.

NOTE: Special instructions should be asked where rule allows thermostat spacing to be over 10 feet, because special conditions may require the Inspection Department having jurisdiction to modify the rule.

(*e*) Under joisted ceiling, open finished, distance between thermostats not to exceed 8 feet at right angles with joists or 10 feet parallel with joists.

Exception: An exception may be made to this rule *if the conditions warrant*, viz. *special permission* may be given to install but one line of thermostats in bays 10 to 11½ feet wide from center to center of the timbers which support the joists. In all cases where such bays are over 11½ feet wide, two or more lines of thermostats should be installed in *each bay* as required by the rules for spacing. This does not apply where beams are flush with the joists, in which case thermostats may be spaced as called for in Rule *e*. Where permission is given, the thermostats should be placed closer together on a line so that in no case will the area covered by a single thermostat exceed 80 square feet. Also see Rule *i*.

(*f*) Under smooth sheathed or plastered ceilings, in bays 6 to 12 feet wide (measurement to be taken from center to center of timber, girder, or other projection or support forming the bay), one line of thermostats to be placed in center of each bay, and distance between the thermostats on each line not to exceed the following: 8 feet in 12 feet bays; 9 feet in 11 feet bays; 10 feet in 6 to 10 feet bays. Bays in excess of 12 feet in width and less than 23 feet in width to contain at least two lines of thermostats; bays 23 feet in width or over to have the lines therein not over 10 feet apart. In bays in excess of 12 feet in width, not more than 100 square feet ceiling area to be allotted any one thermostat.

(*g*) Under a pitched roof sloping more steeply than 1 foot in 3, one line of thermostats to be located in peak of roof, and thermostats on either side to be spaced according to above requirements. Distance between thermostats to be measured on a line parallel with roof. Where the roof meets the floor line there should be a line of thermostats placed not over 3½ feet from where roof timbers meet floor.

NOTE: Two lines of thermostats not more than 2½ feet distance each way from the peak of roof, measured on a line with the roof, may be used in lieu of one line of thermostats located in peak of roof. Also see Sec. *i*.

(*h*) Under open finish, joisted construction floors, decks, and roofs, the thermostats should be "staggered" spaced so that heads will be opposite a point half way between thermostats on adjacent lines, the end thermostats on alternate lines to be not more than 2 feet from wall or partition. Also see Sec. *b*.

NOTE: This regulation does not except thermostats within a bay, whether on one, two, or more lines. Special instruction to be obtained in each case as to whether staggered spacing shall be required under open joist construction, where the channel spaces between joists are positively blocked off within the territory of any two adjacent thermostats.

(*i*) Special instruction to be obtained from the Inspection Department having jurisdiction relative to location of thermostats under floors and roofs of panel or other unusual construction and for which provision is not hereinbefore made.

(*j*) Must be supported in all cases independently of their attachment to the wires, except when cleats or knobs are within one foot of each side of thermostats.

(*k*) Thermostats for hatch closers must be placed at the top of the elevator well or hoistway equipped and on the ceiling below each floor opening in such numbers and so arranged in each case as may be required by the Inspection Department having jurisdiction.

(12) Manual Alarms. Manual alarm boxes must be of an approved pattern; must be used for no other purposes; and must be located as required for Manual Fire Alarm boxes. (See Rule 8, Section *b*.)

NOTE: Manual boxes may be of the type such as is approved for Watchman's Time Recording Apparatus. Central Station Systems, if desired.

CLASS F—AUTOMATIC JOURNAL ALARMS

(13) Circuit and Connections. (*a*) Circuits must be so sub-divided that not more than 25 thermostats will be on any one circuit. There must be a finding switch for each boot in grain elevator equipments and elsewhere when called for by the Inspection Department having jurisdiction. All the finding switches in one circuit must be located in one box. The finding switches to be wired so that the cutting out of one group or boot will not cut off the current from any of the other groups in the same circuit and will show a broken wire when the test is made by the testing apparatus.

(*b*) Connections must be made by running circuit wire without break from the binding posts. Where there is liability of mechanical injury, conductors must be encased in approved flexible, armored, or iron conduits as the special needs of each case require.

NOTE: Armored or iron conduit must be securely fastened in place so as to prevent any strain on the conductors.

Where bearings are not fixed, such as tighteners, etc., a special approved flexible stranded conductor must be used.

(*c*) Circuits must be all metallic and must normally test free from grounds. When open circuit systems are used, they must be so arranged that a single break will not prevent an alarm being transmitted.

(*d*) Thermostats must be on every bearing throughout grain elevators, exceptions only being made by consent of the Inspection Department having jurisdiction. Bearings must be drilled to the full depth of thermostat base where practicable and thermostats must be securely fastened in place.

(*e*) Thermostats must be so arranged that they can readily be taken out of the bearings and disconnected without impairing the wiring or connections in any way, and their connections must be so arranged that journal boxes can be removed and replaced without breaking the wires.

(*f*) Thermostats must be set to give an alarm at approximately 165°F., except by special consent of the Inspection Department having jurisdiction when thermostats may be set at not over 212 degrees.

(*g*) An annunciator must be located near the testing apparatus with the indexes plainly marked to show the various circuits. It must be enclosed in a dust-proof case arranged so that the indexes can be reset from the outside of the case.

(*h*) Independent relays must be used for each circuit; they must be enclosed in a dust-proof case and have spring knife edge contact points in addition to the ordinary relay contacts.

(14) **Gongs.** (*a*) When vibrating gongs are used, all gongs must be of the regular vibrating pattern (not single stroke) and the system must be so arranged that the failure of any one gong to vibrate can in no way interfere with the proper action of any of the other gongs.

(*b*) There must be one 8-inch gong placed over the annunciator in the engine room, which gong shall ring continuously in case of short circuit on system. This gong to be on a relay and separate set of batteries.

(*c*) There must be no gongs in the journal alarm circuit when in normal condition. All gongs must ring from a relay.

Underwriters Rules for Construction and Installation of Automatic Sprinkler Alarm and Supervisory Systems

Central Station. (*a*) From the central office to the protected risk, there must be two separate circuits, one for the water flow alarm, and the other for the supervision features. Manuals must not be installed on the supervision circuit unless of approved, non-interfering pattern.

(*b*) The central office must, at all times, be able to determine from the signal received, the particular feature of the sprinklered risk which is out of order and when it has been restored.

This may be accomplished by having separate transmitters for each feature of the service or distinctive signals from the same transmitter or by a combination of both methods.

Devices, Circuits, Etc. (*a*) Must be so arranged that devices can not easily be tampered with or removed without giving a signal in the central office.

(*b*) All circuits and electrical apparatus must comply with the requirements stated under Class A. It is, however, strongly recommended that all interior circuits be entirely run in approved conduit piping, wire to be such as is required in damp places, under Rule 3, Section "b," Class "A".

(*c*) All pipe connections to sprinkler system must be made in workmanlike manner, equal in all respects to the regular standard required for sprinkler work.

(*d*) Not more than twenty-five (25) sets of transmitters or not exceeding one hundred (100) break wheels must be connected on a single circuit.

Tests. Complete and satisfactory tests of all transmitters must be made by installing companies monthly and results reported to the Inspection Department having jurisdiction.

SUPERVISION DETAILS

Gate Valves. (*a*) Connection, by means of approved devices, must be made to all gate or other stop valves, under control of the assured, in feed pipes to sprinklers, including all valves on tanks, fire pump, steam and discharge connections, city main connections, pump suction, post indicator valves, and where necessary, on small valves used in installation of the service. Devices to be so attached as not to interfere with the operation of the valve nor obstruct the view of indicator or access to stuffing boxes.

(*b*) Attachments on all valves must give a signal between the first and the second revolutions of the hand wheel, tending to move the valve from its proper position, or when valve is not controlled by hand wheel, signal must be given before the valve has moved one-fifth of the stem movement from its proper position.

Two separate and distinctive automatic signals will be required for the gate valve alarm, one signal to show that a valve has been removed from its normal position, and another distinctive and different signal to show that the valve has been returned to its normal position. The latter signal shall not be given until all valves have been returned to their normal position, or at least to the point where the first or trouble signal was given.

Pressure. (*a*) All tanks or their sources of pressure, including steam supply for fire pumps, also pressure on dry pipe system, must be provided with separate and independent attachments, unless otherwise specified by the Inspection Department having jurisdiction.

Pipe to which supervisory devices are connected, must be provided with a plugged test gauge connection and a stop and relief valve of satisfactory pattern; the whole to be so arranged that pressure on attachment and plugged connection can be released for testing purposes.

(*b*) Pressure tank attachment must give a high and a low pressure signal at ten (10) pounds below and thirty (30) pounds above the normal pressure.

Steam pressure attachment must give a low pressure signal at forty-five (45) pounds.

Attachment to dry pipe pressure system must give a high and a low pressure signal at ten (10) pounds variation above or below normal pressure.

In special cases and for other pressure sources, specific instructions must be obtained from the Inspection Department having jurisdiction.

Two separate and distinctive automatic signals will be required for pressure alarm, one to show that the pressure has gone below or above the required amount and another distinctive and different signal to show that the normal pressure has been restored.

Water Levels. (*a*) All pressure and surge tanks, gravity tanks, cisterns, and reservoirs used as a supply for sprinkler systems must be equipped with separate and independent attachments unless otherwise specified by Inspection Department having jurisdiction.

All devices used for this purpose must be designed to withstand corrosion and possible mechanical obstructions.

(*b*) Must give a low water signal in all supplies, except pressure tanks, when water drops 12 inches below the required level. Pressure tank device must give a signal when water drops 4 inches below or rises 4 inches above the required level.

Two separate and distinctive automatic signals will be required for water alarm, one to show that water has changed from the required level, and another to show that the proper water level has been restored.

Temperature. (*a*) All gravity tanks, cisterns, and reservoirs for sprinkler service in which water might freeze must be equipped with suitable temperature indicator, located 2 feet below the required water level.

Note: Where tanks, cisterns, or reservoirs are located in houses in which water might freeze, Inspection Department having jurisdiction may require suitable temperature indicators for such houses.

(*b*) The indicator must give a separate and distinctive signal when temperature falls below 40°F., or rises above 160°F., and another distinctive and different signal to show that water has been restored to the proper temperature.

Fire Pumps. Where automatic fire pumps are used a complete supervision shall be provided in each case, for which special instructions must be obtained.

Water Flow Alarm Details. (*a*) At the base of each system riser, satisfactory and positive connections must be made by an approved device for indicating the flow of water in the sprinkler system, except that due to waste surges or variable pressure.

(*b*) The device must indicate at the Central Station any leak or flow of water in the sprinkler system, equal to or greater than at the rate of ten (10) gallons per minute.

Trouble signal to be distinctive and different from the water flow signal.

(*c*) Where any private local water flow alarm system is in use, the supervisory water flow alarm must be so arranged that it shall not be dependent upon the operation of or interfered with by trouble on the local private alarm circuit.

Manual Alarms. Where a sprinklered risk is provided with either a Central Station Water Flow or a Central Station Supervision Alarm, or both, and has not an approved and properly maintained Automatic Fire Alarm System or Watchman's Central Station Time Recording System, a Manual Fire Alarm System installed in accordance with Rules 8 and 9 must be provided.

Signals and Reports. (*a*) Arrangements must, if possible, be made by the operating company, by which they shall have access to premises under supervision, at all hours of the day and night. Where such arrangements can not be made and it might become necessary to force an entrance to the building, a proper guard shall be placed over the building so long as required.

NOTE: It will, of course, be understood that all arrangements, under the above paragraph, should be made with the owner of the property and must be subject to the approval of the Inspection Department having jurisdiction.

(*b*) Arrangements must be made to furnish such reports of signals that may be received and in such form as may be required by the Inspection Department having jurisdiction.

Disposition of Signals. (*a*) Upon receipt of signals referring to matters of purely equipment maintenance, the operating company must immediately send a runner to investigate and, if possible, see that the trouble is remedied at once.

They shall also notify the assured by telephone or by the quickest method available.

Written notice should be given the assured in all cases.

(*b*) Upon receipt of signals showing flow of water in the system, the central office must notify the nearest Insurance Patrol and such other parties as the Inspection Department having jurisdiction may require.

They shall also dispatch a runner to the risk.

They shall also notify the assured by telephone or by the quickest method available.

In addition to which, written notice should be given to the assured.

NOTE: In all cases where notification is required to parties with whom private lines of communication have not been provided, the quickest available means of communication must be used.

(*c*) If, at any time, a combination signal is received, which, from its nature, is indicative of water flow on the premises equipped, such combination signal must be treated by the central office as a fire alarm.

All manual alarms are to be treated as fire alarms.

NOTE: Fire alarms received from Sprinkler Supervisory service shall be transmitted to the city fire alarm office and patrol or such other place as required by the Inspection Department having jurisdiction, and should at all times be treated as still alarms.

LOCAL SYSTEMS

Alarm Details. (*a*) Must be arranged to give signals at points designated by the Inspection Department having jurisdiction.

These connections should be chosen from the following, choice being made in the order given.

1. Fire department house within 2,500 feet, having men and horses stationed therein.

Note: In certain large cities the above connection alone will be required.

2. Fire department house within 2,500 feet, having "bunkers" and horses at night.
3. House of engineer or fireman of risk, when same is within 1,200 feet.
4. House of owner or superintendent of risk, when same is within 1,200 feet.
5. House of chief engineer or foreman of local fire department, when either is within 1,200 feet.
6. House of regular employe, other than those above mentioned, when same is within 1,200 feet.

When it is impossible to obtain any of the above, special instructions shall be obtained.

Connection to city or town fire alarm box is not allowable.

Gongs. Must be not less than 6 inches in diameter. Where there is only one outside connection, gong shall be of vibrator pattern. Where there are two outside connections, gongs to be wired in series, a vibrator being placed in principal one, and a single stroke in the other.

Testing of Local Electric Alarms. (*a*) System to be tested daily by closing a circuit through the binding posts of the alarm valve. Test to be recorded by a device which shall make a series of punctures on a dial showing the vibration of the main gong. This device to be of single stroke pattern normally out of main circuit (*i.e.*, in the test circuit connecting the binding posts) in series with and vibrated by main gong.

Note: Inspection Department having jurisdiction should be consulted as to the necessity for installing the testing device, called for below.

(*b*) Switches for cutting out alarms are prohibited.

PRIVATE FIRE DEPARTMENTS

One of the most important organizations for fire protection is the private fire department. Such an organization, if properly formed and drilled, may prove very effective in handling fires in mill and shop plants, railroad terminal yards, department stores, theaters, schools, and similar risks.

The following rules for organizing a private fire department were drawn up by the late W. H. Stratton and are recommended by he National Fire Protection Association.

SUGGESTIONS FOR ORGANIZING PRIVATE FIRE DEPARTMENTS

Chief. The active resident manager, superintendent, or any one who is ordinarily in high authority on the premises.

• **Assistant Chief.** Master mechanic or some one ordinarily in constant attendance at the property and high in authority in the administration of the men.

Battalion Chief. Where the department is divided into battalions a battalion chief should be assigned, and his selection should be based upon the same qualifications as assistant chief, in addition to which this office could be made the subject of promotion from captains of companies who have evidenced especial merit or who have had experience in fighting fires.

Organization of Companies.

NOTE: While special duties are suggested for members of a company as given in detail below, it is obvious that every man in the Department should be instructed and drilled so that he may perform any of the duties outlined in the suggestions. By this program each man will be available for whatever duty may be assigned him at the time of fire.

Captain. For this position a mechanic or a man with mechanical experience should be selected, preferably one usually in charge of a department and accustomed to the control of men.

Hydrant Men. Two men should be selected for this service whose special duty should be to attend to turning on and off the water, and connecting and disconnecting the hose at the hydrant; one man should be left at the hydrant; the other could assist in adding or taking out hose, replacing for breaks, etc.

Pipe Men. For each company there should be three sets of pipe men, composed of three men each; these men should be heavy and strong, and practiced in holding play pipes; two men ordinarily can hold a stream under average pressure, but when hose is taken up ladders, used on roofs, in buildings, or under high pressure on the ground, three men are not too many to properly hold, move, and direct a fire stream.

Extra Hose Men. For each company there should be three extra hose men to assist in drawing the hose carts and laying the lines. The total strength of a company need not exceed twelve men, and where only *two-way hydrants* are in use, two sets of pipe men would be sufficient, making the company consist of nine men in all.

NOTE: An organization consisting of several companies, composed of a small number of men in each, makes it possible for the chief to direct through the captains the application of fire streams with the least confusion to the whole force, especially under excitement during a fire.

When the force consists of more than five companies, it should be divided into battalions of three companies each, and each battalion should have a chief who should be selected for his coolness and general knowledge of the property.

Ladder Companies. Where there are high buildings, ladder companies, independent entirely of the hose companies, should be organized, composed of a captain and six men to each company. Permanent ladders can often be placed at small expense where they would greatly facilitate the work of firemen.

Selection of Men. The selection of men for a fire department should be made from intelligent mechanics, preferably the strong and reliable men, generally known to be cool headed and well posted as to all the buildings, the location of the stairways, elevators, etc., and also care should be taken to appoint those living within hearing distance, if possible, of the fire signal.

For identification and admittance to the premises during night or holidays, each member of the department should be provided with a badge to be worn at all times.

Fire Drill. Practice drills should be held as frequently as possible, both at regular stated intervals and also at time without notice, in order to test the readiness of the department to respond to an actual fire call. It would also be desirable to arrange for an occasional night drill of similar sort.

This practice should consist of laying lines of hose and carrying them onto and into different buildings (without turning on water), in order that the men may become accustomed to handling the hose and making the connections with the couplings with rapidity, at the same time avoiding confusion.

It is well to select for each trial a different building, assuming the one selected or the adjoining one to be on fire; then have the chief engineer direct where the ladders should be placed and where streams should be carried, and where practicable, water should be turned into hose that is carried up ladders and onto roofs, in order that the firemen may become accustomed to the "recoil" and weight to be managed.

To protect the men from accidents on ladders, ladder straps should be attached to all hose carried onto buildings, to take the weight and recoil on the ladder and off from the men.

A stream should never be manned on the roof with less than three men, and they should be reinforced by two extras to pass signals and to assist in case the hose becomes unmanageable.

During fire practice, special attention should be given to the laying of hose without twists or kinks, and it should be especially understood that there should be no short turns any where in the length of hose, and that the play pipes shall be so held as to make a gradual curve in the hose from the ground up.

This is an important feature in handling hose for the following reasons:

1. Kinks or twists are liable to pull the hose away from the pipemen when water is turned on.
2. If there are any short bends near the play pipes it makes it almost impossible to hold the pipe, when, if it is under easy curve, the recoil is reduced to a minimum.
3. The hose is liable to burst by opening up a kink or short turn when the water is turned on or to burst if a kink or short turn is taken in it while water is turned on.

Pumps. *Steam.* In addition to the foregoing organization there should be an engineer in charge of the pumps and boilers to see that steam is kept up, and that the pumps are operated in accordance with the demands made upon them—that is, not to run the pumps faster than is necessary, and when they are driven to maximum speed to see that they are managed without danger of breakage.

Arrangements should also be made that in the event of extended service, extra men to fire the boilers should report to the Chief Engineer, as the consumption of steam by fire pumps requires steady firing, generally too much for the ordinary force of firemen at boilers.

Rotary. Where rotary pumps furnish water supply for fire protection, one or more men should be detailed to operate the gearing, start the pumps and keep them well oiled, and give them such other care and attention while running as will prevent accident from overspeed or heating of the boxes.

Where the ordinary heavy grease is not at hand for prolonged use of rotary pumps, they may be kept cool by pouring on water.

Water Pressure. In all cases, either on steam or rotary pumps, pressure should be gauged to suit the height of buildings, and relief valves set accordingly. One hundred pounds' pressure at pumps is in most cases the maximum pressure necessary; if a greater pressure than one hundred pounds is attempted, first-class fire hose, specially selected to stand a high pressure, should be provided.

Fire Alarm Systems. The noise of machinery within buildings sometimes prevents the distinct hearing of whistle or bell alarm; for this reason it is best to have one signal for FIRE or GENERAL ALARM, which will call the men out of the building, and when they are out where they hear distinctly, and while they are on their way to the stations or hose carriages, the signal can be blown or rung designating the exact location of the fire.

Fire Alarms. A system, preferably of steam whistle signals, should be arranged and practiced with upon the following general idea:

1. *General Alarm.* A general alarm which will summon the men from their work or their homes to the property; upon this alarm men should immediately report to their assigned stations, and the engineer in charge of the pumps should make preparation to operate them and see that his fires are in condition to maintain them, and in most cases he should start up his pumps without further orders.
2. *Location Alarm.* This alarm should be signal numbers, designating certain localities or buildings. At this alarm the hose and ladder companies should proceed to the location and the captain report to the chief or battalion chief, who will give orders for going into action.

Where bells are used in place of steam whistles for alarm, the arrangement would be practically the same as to *General* and *Location* alarms.

Salvage Corps. A certain number of employes of known ability and special qualifications should be organized and instructed concerning the best course to follow in covering up valuable stock and machinery to prevent water damage; sweeping out, draining off, and soaking up water; caring for belts, dynamos, card clothing, and other machinery or material peculiar to the property that may be susceptible of excessive water damage.

This organization should be provided with all the necessary paraphernalia, such as rubber blankets or whatever may be needful to cover up and take care of the contents of the building, either the machinery or the stock.

Co-Operation with City Fire Departments. If the property be located where it is under public fire department protection, every one, from the highest in authority to the lowest one in the organization liable to be brought in contact with the question, should be thoroughly posted as to their own rights of operating the private apparatus, and also the rights of the public fire department to enter the premises at time of fire.

It would seem advisable that this should be explained in a printed card or poster very generally in conspicuous places throughout the property.

It would also seem desirable to invite the authorities of the public fire department to the property to explain to them the use of the private apparatus, to show them the location of all valves and the purpose for which they are intended.

At the same time it would be desirable to have the members of the nearest public fire companies inspect the property until they become familiar with the arrangement of buildings; also in order to find out the best means of access and escape from the various buildings, and furthermore looking into the nature of the contents and taking especial note of the places where they may be chances of an explosion or rapid spread of fire.

Drill to Avoid Panic. In this connection it would be advisable for the assured to arrange for a simple but effective plan by which all of the help may be promptly dismissed from the premises without possibility of confusion or panic. This is most necessary in large factories where the help is composed mainly of girls or where material is worked that permits of a rapid spread of fire. Instructions as to this particular drill should be posted on cards in conspicuous places.

General Notes. It would be advisable to have a plan of organization of the fire department posted in conspicuous places throughout the property so that the men may become familiar with the arrangement.

For use during fire drill and generally for extra strong streams from the ground, a nozzle rest selected from the several patterns made should be provided, by the use of which one man can hold and guide a fire stream that would otherwise require three men to handle.

The nozzle rest will be found to pay for itself in small mill yards, where trial of streams for inspectors would ordinarily call out a large number of men to man the pipes; by the use of a nozzle rest, one man can serve a fire stream for all ordinary purposes of inspection or trial, which in the course of a year makes quite a saving.

Frequent inspection of the fire department equipment should be made to watch the condition of hose, which is liable to deteriorate, and also to prevent the misplacing of play pipes, axes, spanners, and crow-bars.

Play pipes should be handled carefully, so as not to dent or bruise them; the smoothness of bore in them is as important for a perfect stream as in the barrel of a gun for its accuracy.

The following implements are necessary for a complete equipment of a private fire department in proportion to the demands of the property:

First: Sufficient fire hose to concentrate the total capacity of the water supply upon any building or section of the property.

Second: A liberal supply of Underwriters' standard play pipes, so that the streams may be obtained without delay in gathering them during a fire.

Third: Spanners should be supplied in liberal numbers and distributed throughout the hose house equipment and on the hose carriages. In many cases they can be carried in the men's belts.

Fourth: Fire axes and bars of standard size and pattern should be carried on all hose and ladder carts in liberal quantities.

Fifth: Ladder straps, for the purpose of fastening hose to the rounds of ladders and to window sills and other places where the weight of hose and the additional strain of the weight and recoil of water would otherwise make them unmanageable.

Sixth: Coils of ½-inch hemp rope with snap hooks should be provided for the ladder and hose companies, the length to be about two and one-half times the height of the highest building.

Seventh: Fire lanterns. There should be a liberal supply of fire lanterns, of the pattern which will prevent the lamp being dropped through the bottom of the body, or extinguished by a stream of water striking it; the glass should also be guarded by a steel or wire fender.

Eighth: Provision should be made for hoisting hose, so that it can hang above ground vertically on supports to drain and dry in good shape. This is best obtained by a frame hung over a mill tower, and as all hose is made in fifty feet lengths the required height will be easily determined.

PRIVATE FIRE DEPARTMENT ORGANIZATION

CHIEF—ASST. CHIEF—BATTALION CHIEF

HOSE COMPANIES:

Captain—Hydrant men, (2)
Pipe men (3) for each hydrant outlet
Extra hose men (3)

LADDER COMPANIES:

Captain—Six ladder men

SALVAGE CORPS:

Number of men to be determined
by size of property

PUMP MEN

STEAM PUMP	ROTARY PUMP
Engineer in charge	Engineer in charge
Extra men to fire boilers	Extra men to assist

Special Note. The foregoing detailed suggestions for the formation and maintenance of a large or small private fire department will be found to embrace sufficient general data upon which to base an organization for special emergencies such as may be found, particularly in department stores. In applying these suggestions, however, to meet the needs of these special cases, the application of the recommendations will devolve upon the persons in charge of each individual property.

Notes. While this is the first occasion upon which consideration has been given this subject by this association, it is a well-known fact that many large properties having individual fire protection have for several years past supported private fire departments thoroughly organized and drilled and in full harmony with the public department, and it is needless to say that this arrangement greatly enhances the value of the apparatus at the risk, as well as being of more assistance to the public department.

In view of the well-known importance of this subject, your committee feels that it will be desirable to print for general distribution the suggestions embodied in this report, being very particular to point out that they are not fixed rules to be applied to every property, but merely contain ideas for consideration and application to such extent as the needs of each particular case demand.

Watchman Service. A watchman service without proper supervision over the watchman's performance of his duties is manifestly of little value and consequently is not recognized by insurance underwriters. To make a watchman service efficient, the watchman should visit certain designated places or stations at regular intervals, and at these stations he should record the time of his visit. There are three methods of making this record, viz, the Central Station System, the Stationary Recorder, and the Portable Recorder.

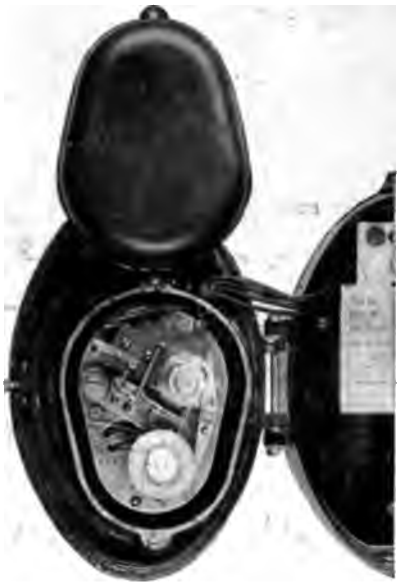


Fig. 161. Interior View of Watchman's Signal Box

The Central Station Systems, usually managed by certain telegraph or burglar alarm companies, have a type of signal box similar in many respects to a fire alarm box, Fig. 161. It is usually operated by inserting a key and winding a spring. The releasing of the spring sets a toothed wheel revolving which makes electrical contact with a registering device in the Central Station, Fig. 162. Each station box has a special number and the teeth on the wheel are spaced to correspond with this number. The registering device at the Central Station prints on paper tape a mark for each tooth on the wheel. When the signal is transmitted to the Central Station the operator notes the time it is received on the register tape. A schedule time is set for the watchman to visit the stations, and if the signal is not received within ten minutes of the schedule time a reserve watchman or "runner" at the Central Station is sent to investigate the reason. In case of need this man performs the duties of the regular watchman. A daily statement of the watch service is furnished to interested parties by the Central Station.

These watch station boxes are also arranged to transmit a fire alarm signal. In one type of station box there is a small piece of glass set in a corner of the box cover, Fig. 163. By breaking the glass the box may be opened and a lever, Fig. 164, pulled down which winds up the spring that operates the toothed wheel. The wheel is given seven revolutions which transmits the regular watch signal and repeats it seven times, each time preceded by the Morse symbol for the letter F, and which means fire.

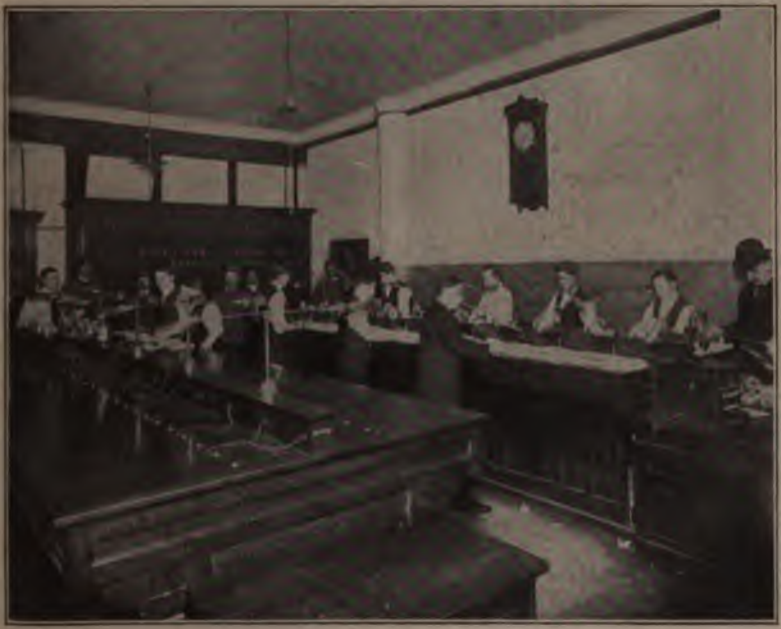


Fig. 162. Interior of a Central Alarm Signal Station

The advantages of this fire alarm box is that it is within easy reach of the watchman or other persons, and when the signal is received at the Central Station it is able to notify the Fire Department not only that the fire is in a certain building but also that it is in a certain definite part of that building.

The stationary recorder and portable recorder are usually clock mechanisms. The recording device each time it is operated makes a distinctive mark on a sheet of paper divided into hours and minutes. These clocks make available a record of the watchman's patrols but exercise no supervision over his work as does the Central Station.

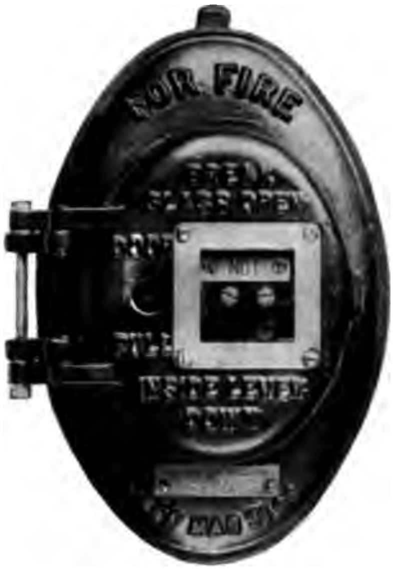


Fig. 163. Fire Alarm Box for Watchman's Use. Glass Sealed

The stationary recorder is in appearance much like an ordinary office clock, Fig. 165. It is operated by electricity, and the marking mechanism is a needle point held back of the paper record. The point is on one end of a pivoted lever bar and at the other end there is an electro-magnet. The lever bar is attracted and forces the point into the paper record whenever electricity

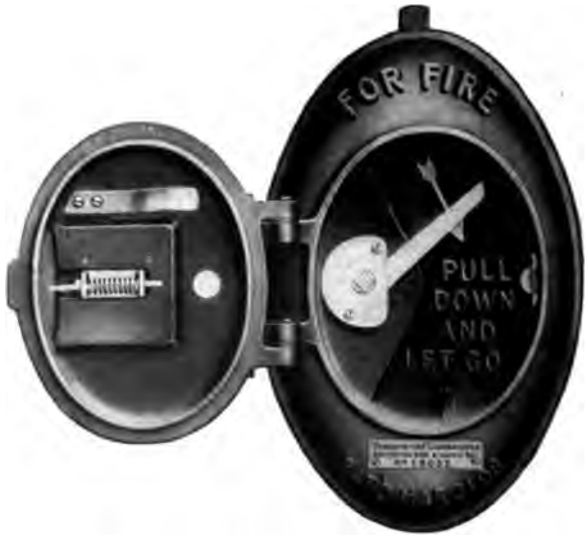


Fig. 164. After Breaking Glass Shown in Fig. 163, Box Is Opened and Lever Operated

ows through the coil of wire around the magnet. At each station iere is a box containing a small generator, Fig. 166. This generator r magneto produces an electric current when operated by turning

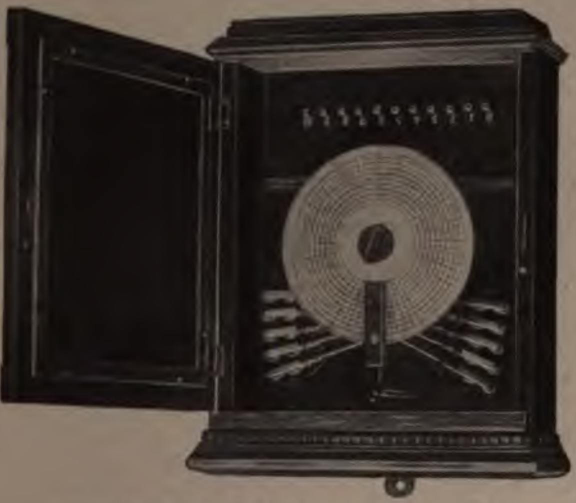


Fig. 165. Stationary Watchman's Recording Clock

andle which is carried by the watchman. The electric current duced by turning the handle operates the marking device in the order.

The portable watch clock, Fig. 167, is similar in size and shape an ordinary alarm clock. It is carried in a leather case suspended

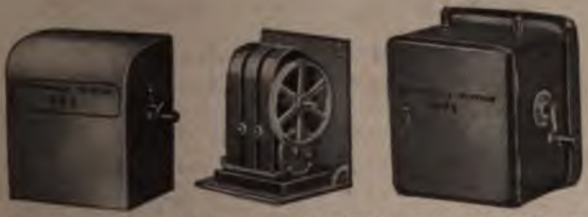


Fig. 166. Magneto Generator Used at Each Watchman's Station to Operate Recording Service

n the shoulder by a strap. The record is made on a paper dial inserting a key. Each station has a special key which when erted in the clock punches or embosses the paper dial. As this l revolves with the working of the clock, the exact time the key s used is shown on the paper.

The requisites for an approved watchman and clock service are as follows:

1. Patrols to be made every night, also during the day time on Sundays and holidays, and at all other times when business is suspended.
2. Patrols to be made hourly, and to begin immediately after the day's business is ended, and to continue until just before the day's business is resumed.
3. Stations to be so located that the watchman will be compelled to traverse every part of the premises. Stations to be numbered in the order the watchman is required to make his patrol.
4. The watchman's records to be preserved for at least thirty days.
5. The watchman's lantern to be of the locked safety pattern, with the oil pot permanently fastened, or if removable, to be contained within the lantern base and removed by lifting from the top. To burn only signal, lard, or sperm oil.

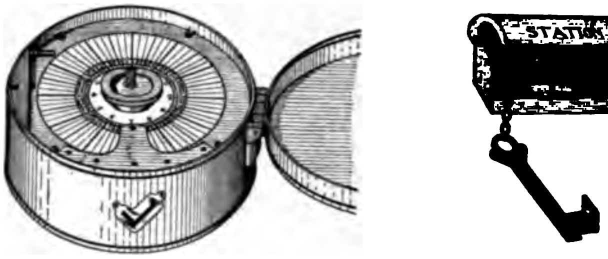


Fig. 167. Watchman's Portable Recording Device

RULES AND REQUIREMENTS OF THE NATIONAL BOARD OF FIRE UNDERWRITERS

WATCHMAN'S TIME RECORDING APPARATUS

Central Station Systems. (*a*) Must not have more than forty boxes connected on a single circuit, nor shall more than five watchmen report on a single circuit.

(*b*) Must be so arranged that fire signals which shall be distinct from watch signals can be sent from each station installed.

(*c*) Watch boxes must be of an approved pattern, must be used for no other purpose, and must be located as required by the Inspection Department having jurisdiction.

When specific locations of watch boxes are not furnished by the Inspection Department having jurisdiction, they must be located so that the watchman in his rounds will cover plant, and, in addition, must conform with the following:

Must be located so that from any part of the plant equipped, not more than 200 feet will have to be traversed in order to reach a box.

Must, where buildings are more than one story in height, have a box on the first story, and at least one in alternate stories, *i.e.*, 3d, 5th, 7th, etc. Where buildings have single floor area of 7,500 square feet, or over, there shall be at least one box on each floor.

Must, where any plant or building equipped is divided into sections, have e boxes in each section located to agree with above rules, account not being ken of boxes in any other section.

(*d*) Complete and satisfactory tests all transmitters must be made by in-lling companies monthly and results orted to the Inspection Department ving jurisdiction.

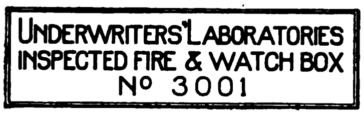


Fig. 168. Underwriters' Laboratories Label for Inspected Watchman's Clock

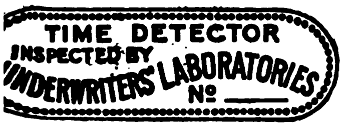
Local or Private Stationary Sys-ns. (*a*) The clock used must run for least eight days without rewinding, and must be so encased that watch ord dials can not be seen without opening door, and so arranged that open-g or closing of door will make a distinctive record on dial, this to be done by echanical means.

(*b*) Records must be made by perforating a paper dial and the punctur-g device must be so arranged that it is not liable to stick in, adhere to, or tear e dial.

(*c*) Magnetos must be used for the transmission of signals, must be of n approved type, and may be either portable or fixed at each station.

NOTE: Where single station clocks are employed the recording apparatus may be erated by an approved mechanical device.

(*d*) Stations must be placed as required by the Inspection Department ving jurisdiction.



g. 169. Underwriters' Laboratories bel for Watchman's Time Recorder

Portable Watch Clocks. (*a*) The clock used must run for at least 48 hours without rewinding, must be substantially mounted and strongly encased. It must be made so that the watch record dial can not be seen without opening the case and so that it can not be opened without puncturing or cutting the dial.

(*b*) Records must be made by embossing or puncturing the dial and must asily legible. Dial must be of sufficient size so that time at which the rd is made can be accurately determined.'

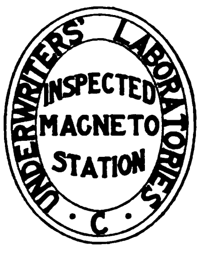


Fig. 170. Underwriters' Laboratories Label

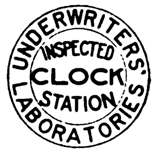


Fig. 171. Underwriters' Laboratories Label

(*c*) Stations must be located as required by the Inspection Department ving jurisdiction, and fixed so they can not be removed without giving idence of the fact.

Keys must be made so that they are difficult to duplicate, and must be of a pattern susceptible of variations tending to reduce the probability that a set of keys fitted for one clock will operate other clocks.

Boxes for Central Station Systems. Combined Watchmen's Call and Fire Alarm Boxes for use in connection with approved normally closed circuit Central Station Watchmen's Time Recording Apparatus, shown by tests and examinations conducted by the Underwriters' Laboratories to be in accordance with the rules of the National Board of Fire Underwriters, and examined at factories and passed by Underwriters' Laboratories, Inc., can be distinguished by labels fixed to the outside of the clock cases reading as in Fig. 168.

Apparatus for Local or Private Systems. Watchmen's Time Recorders shown by tests and examinations conducted by Underwriters' Laboratories to be in accordance with the rules of the National Board of Fire Underwriters, and examined at factories and passed by Underwriters' Laboratories, Inc., can be distinguished by labels fixed to outside of clock cases reading as in Fig. 169.

A decalcomania transfer is applied to the outside of the clock station cases reading as in Figs. 170 and 171.

FIRE INSURANCE INSPECTION

PART IV

PUBLIC FIRE PROTECTION

WATER SUPPLY SYSTEMS

Introduction. Judged from a fire insurance standpoint the value of the water supply at any particular place depends *first*, upon the maximum amount of water; *second*, upon pressure or mechanical means available for putting this water onto a fire; and *third*, upon the degree of dependability of both these requisites. As these, in turn, depend upon the source of the water supply and the method of distribution, it is evident that the problem of judging the adequacy of the water supply at any definite point is a complex one, necessitating an intelligent examination of the entire water supply system. The inspector must possess not only a knowledge of the fundamental laws governing the action of water and a working knowledge of the principles of pumps, piping systems, standpipes and other apparatus used in distributing water in cities and towns, but—what is perhaps most important, from the fire insurance standpoint—he must possess an ability to judge whether the maximum supply upon which reliance can be made will be equal to the probable maximum emergency demand. The following discussion, therefore, will present such physical principles and practical information as is necessary to carry out the proper functions of an inspector as regards the water supply for fire purposes.

ELEMENTARY PRINCIPLES

Laws of Hydrostatics. Water is either at rest or in motion. The science which treats of water at rest is called hydrostatics; that which treats of water in motion is called hydraulics. A knowledge of the laws governing pressure in water and the flow of water in pipes is essential to the understanding of our subject. For the Elementary

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TABLE IV

Converting Feet Head into Pressure Per Square Inch of Water

Feet Head	Pounds Per Sq. In.	Feet Head	Pounds Per Sq. In.	Feet Head	Pounds Per Sq. In.	Feet Head	Pounds Per Sq. In.
1	.43	30	12.99	95	41.14	250	108.27
2	.87	35	15.16	100	43.31	275	119.10
3	1.30	40	17.32	110	47.64	300	129.93
4	1.73	45	19.49	120	51.97	325	140.75
5	2.17	50	21.65	130	56.30	350	151.58
6	2.60	55	23.82	140	60.63	375	162.41
7	3.03	60	25.99	150	64.96	400	173.24
8	3.40	65	28.15	160	69.29	500	216.55
9	3.90	70	30.32	170	73.63	600	259.85
10	4.33	75	32.48	180	77.96	700	303.16
15	6.50	80	34.65	190	82.29	800	346.47
20	8.66	85	36.81	200	86.62	900	389.78
25	10.83	90	38.98	225	97.45	1000	433.09

discussion of Pascal's Law and its operation, and other physical theory on the subject of water pressure, the reader is referred to Practical Physics, Part I.

The statement of Pascal's Law is as follows:

Pressure exerted anywhere upon a water surface is transmitted equally in all directions and acts with the same force on all equal surfaces and in a direction at right angles to those surfaces.

An important outgrowth of this law may be stated thus:

The pressure at any level in water is constant and corresponds to the depth of this level below the water's surface.

Weight of Water. In many hydraulic problems, air pressure may be neglected although it varies with temperature and with the height above sea level. For all altitudes and temperatures with which we are interested it is practically constant and is approximately fifteen pounds per square inch. The weight or pressure, of water also varies according to its temperature, and to the substances which it may have in solution, yet in ordinary computation the values generally used are:

One cubic foot of fresh water weighs 62.5 pounds
One cubic foot of ocean water weighs 64 pounds

Using these values it will be found that a column of water with a cross section of one square inch and a height of one foot will weigh

TABLE VII

Converting Pressure Per Square Inch Into Feet Head of Water

Pounds Per Sq. In.	Feet Head	Pounds Per Sq. In.	Feet Head	Pounds Per Sq. In.	Feet Head	Pounds Per Sq. In.	Feet Head
1	2.31	30	69.27	95	219.35	250	577.24
2	4.62	35	80.81	100	230.90	275	643.06
3	6.93	40	92.36	110	253.98	300	692.69
4	9.24	45	103.90	120	277.07	325	750.41
5	11.54	50	115.45	130	300.16	350	808.13
6	13.85	55	126.99	140	323.25	375	865.89
7	16.16	60	138.54	150	346.34	400	922.58
8	18.47	65	150.08	160	369.43	500	1154.48
9	20.78	70	161.63	170	392.52		
10	23.09	75	173.17	180	415.61		
15	34.63	80	184.72	190	438.90		
20	46.18	85	196.26	200	461.78		
25	57.72	90	207.81	225	519.51		

$\frac{62.5}{144}$, or .433 pounds; therefore, in order to produce one pound pressure a column of fresh water must be $\frac{1}{.433}$, or 2.309 feet high.

It is a matter of common practice to neglect air pressure and to state water pressure or "head" not in pounds per square inch but by the height in feet of the column of water which would produce this pressure. For example, a pressure of ten pounds is the same as the pressure of a column of water 23.09 feet high; so this pressure would be stated as "23.09 feet head." Tables VI and VII are derivedaccording to this method.

Water at Rest. Our own observation satisfies us that the surface of water in any vessel is always level. This follows from Pascal's law; for if the surface were not on a level the pressure at any given level below would vary from place to place since the depth of water at any one point would be different from that at any other—a condition which we know from the second law quoted is impossible. This is true not only for a single vessel but for a series of vessels con-

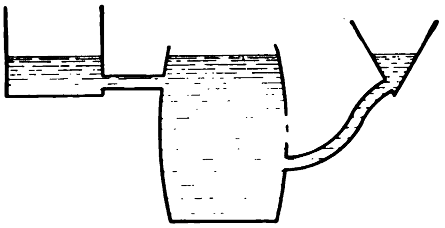


Fig. 172. "Water Seeks its Level"

nected by pipes as in Fig. 172. If we pour water into one of these vessels, it will rise in the others and will not come to rest until the surfaces in all the vessels have reached the same level. This also follows from Pascal's law, for if we imagine a small movable partition across the pipe connecting two of these vessels, then the pressure on each side of this partition will be proportional to its area and to the height of the water above it on that side. Unless this is the same on both sides the partition will move in the direction of the smaller force and the water will continue to flow until it has reached the same level in all vessels and until an equilibrium of pressure is established throughout. The rule growing out of this principle may be stated thus:

Water will not come to rest until all its free surfaces are at the same level.

Gravity Systems. It is upon the principle just stated that gravity systems of distribution depend. The water is stored in a reservoir or tank elevated above the place to be supplied. It is evident that the greater the elevation of the stored supply, the greater will be the water pressure in the town. The level of the pipes which distribute the water varies from place to place, sometimes rising to the top of high buildings or to a high point of land. The pressure from the reservoir or tank forces the water down into the distributing system and it rises in the pipes to the high parts of the city and into the high buildings by the same principle as that by which it rose in the series of communicating vessels. In other words, the water will come to rest only when all of its surfaces are on the same level, that is, when an equilibrium of pressure has been established.

Hydraulic Gradient. From this it is evident that there is a limiting height to which water will rise in the distributing pipes and this limit, when no water is being drawn from the system, is the height of the surface of the water in the distributing reservoir. Suppose, however, that in carrying water up a hill the pipes reach this maximum height; the water at this point is then under no pressure whatever. Furthermore, from any actual system, water is constantly being drawn, and this flow reduces the height to which the water can rise. The level to which water will rise in any given system is called its "hydraulic gradient," and this level, of course, varies as the amount of water being drawn from the system increases and

:creases. In examining a system, care must be taken to see that at) place are the pipe lines so high that water can not be supplied iere when the draught elsewhere is great. If this height above the ·draulic gradient is simply a hill or ridge beyond which the level the city is low again, the water may be carried over the height to ie section beyond by means of a siphon, as described in Practical hysics Part I, and also later in this article.

High and Low Service. If, however, this high section covers a rge area, it may require a separate distributing system with the essure obtained either from an additional reservoir or by direct imping. Cities having more than one level and requiring different essures in different sections are said to have "high and low service."

LAWS OF WATER FLOW

Velocity of Efflux. Imagine a tank in which the water is main- ,ined at a constant height by water flowing in at the top, and which is attached near the bottom a hose and nozzle. From considerations ready given in Practical hysics, the rate of flow from iis nozzle depends upon the ressure. Let *H*, Fig. 173, present the difference in eight in feet between the vel of the nozzle and the vel of the water in the tank. ecause of its greater height, ie water entering the tank is greater potential energy than the water leaving the nozzle, the nount of energy in foot pounds being equal to the product of the eight *H* by its weight, that is, *H* foot pounds per pound of ater. This potential energy of the water in the reservoir develops : the nozzle orifice a certain amount of pressure which is capable of ving to the water the equivalent *kinetic* energy, or energy of motion. rom Practical Physics Part II the amount of this energy is propor- onal to the amount of the water and to the square of its velocity, · for each pound of water the energy is V^2 foot pounds, where V is s velocity in feet per second and g is the increment of gravity, or $2g$ ie amount that the velocity of a falling body would increase each

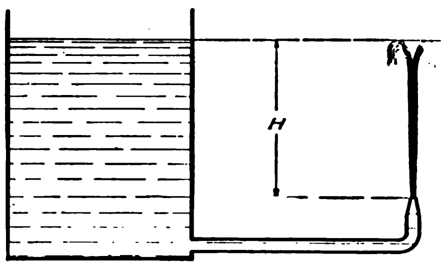


Fig. 173. A Stream of Water Rises as High as its Source

TABLE VIII

Fire Streams

FROM TABLES PUBLISHED BY JOHN R. FREEMAN, M. E.

Pressure at Nozzle	Gallons Discharged Per Minute	Vertical Distance of Stream for Good Fire Use	Horizontal Distance of Stream for Good Fire Use	Pressure in pounds required at Hydrant or Pump to maintain pressure at nozzle through various lengths of 2½-inch smooth, rubber-lined hose								
				50 Feet	100 Feet	200 Feet	300 Feet	400 Feet	500 Feet	600 Feet	800 Feet	1000 Feet
1⅛ INCH SMOOTH NOZZLE												
35	222	59	54	43	49	60	71	82	94	105	127	149
40	238	65	59	50	56	69	81	94	107	120	145	171
45	252	70	63	56	63	77	92	106	120	135	163	192
50	266	75	66	62	70	86	102	118	134	150	181	213
55	279	80	69	68	77	95	112	130	147	165	200	235
60	291	83	72	74	84	103	122	141	160	180	218	256
65	303	86	75	81	91	112	132	153	174	195	236	...
70	314	88	77	87	98	120	143	165	187	209	254	...
75	325	90	79	93	105	129	153	177	201	224	...	...
80	336	92	81	99	112	138	163	188	214	239	...	...
85	346	94	83	106	119	146	173	200	227	254	...	...
90	356	96	85	112	126	155	183	212	241	...	...	...
95	366	98	87	118	133	163	194	224	254	...	...	...
100	376	99	89	124	140	172	204	236	...	...	...	...
1¼ INCH SMOOTH NOZZLE												
35	277	60	59	48	57	74	91	109	126	142	178	212
40	296	67	63	55	65	84	104	124	144	164	203	243
45	314	72	67	62	73	95	117	140	162	184	229	...
50	331	77	70	68	81	106	130	155	180	204	254	...
55	347	81	73	75	89	116	143	170	198	225	...	...
60	363	85	76	82	97	127	156	186	216	245	...	...
65	377	88	79	89	105	137	169	201	234	...	...	...
70	392	91	81	96	113	148	182	217	252	...	...	...
75	405	93	83	103	121	158	195	232	...	...	...	...
80	419	95	85	110	129	169	208	248	...	...	...	...
85	432	97	88	116	137	179	221	...	...	...	...	
90	444	99	90	123	145	190	234		...	...	...	
95	456	100	92	130	154	201	247	...	...	...	...	
100	468	101	93	137	162	211	261	...	...	...	...	...

second. If we neglect the loss of energy due to eddy currents and to friction against the pipes due to the motion of the water, then these two expressions, one representing the potential energy of the water in the tank and the other representing the kinetic energy of the water as it issues from the nozzle, must be equal; that is,

$$H = \frac{V^2}{2g}$$

The velocity V is exactly that which would be acquired by the water falling from the height H. Therefore, if the nozzle were directed upward, the water would rise with a velocity V and would not stop until the jet had reached the level of the water in the tank.

Principles of Hose Streams. It is upon the principle just stated that the action of hose streams depends. The water as it leaves the nozzle is endowed with a sufficient amount of kinetic energy to send it upward to a height equal to the height of its course, neglecting the losses due to pipe and air friction. If the stream be directed in any other direction it will travel until the attraction of gravity brings it to earth, or until it has come into contact with some other body and its energy expended in heat. Table VIII gives data concerning hose streams produced by different pressures.

Velocity of Jets. The velocity with which this jet is projected may be found by solving the equation already given for V, viz,

$$V = \sqrt{2gH}$$

where H is the height of water about orifice, *i.e.*, the feet head at that point; and g is 32.2 feet, the acceleration of gravity. This is called the theoretical velocity. The actual velocity varies according to conditions, but the average lies between 97 to 99 per cent of the theoretical velocity. This quantity expressing the ratio between the actual and theoretical value is called the *coefficient of velocity*. Representing it by C_v, we have

$$\text{actual velocity} = C_v \sqrt{2gH}$$

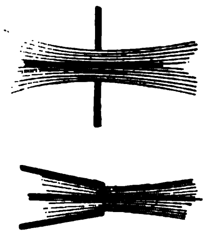


Fig. 174. Shape of Streams from Different Orifices

Discharge. A stream of water issuing from an orifice, Fig. 174, contracts 60 to 70 per cent of the area of the orifice from which it issued. This factor showing the per cent of contraction is called the coefficient of contraction and may be represented by C_c. Since the amount of water flowing past one point in this stream must be the same as the

TABLE IX

Values of Coefficient of Discharge for Circular Vertical Orifices (Smith)

Head, h, in Feet	Diameter of Orifice in Feet 0.02	0.04	0.07	0.10	0.2	0.6	1.0
0.4		0.637	0.624	0.618			
0.6	0.655	.630	618	.613	0.601	0.593	
0.8	648	626	615	.610	.601	.594	0.590
1.0	644	.623	612	.608	.600	.595	.591
1.5	637	618	.608	.605	.600	.596	.593
2.0	632	614	.607	.604	.599	.597	.595
2.5	629	612	605	.603	.599	.598	.596
3	627	611	604	.603	.599	.598	.597
4	623	609	.603	.602	.599	.597	.596
6	618	607	.602	.600	.598	.597	.596
8	.614	605	.601	.600	.598	.596	.596
10	.611	603	.599	.598	.597	.596	.595
20	601	599	.597	.596	.596	.596	.594
50	596	.595	.594	.594	.594	.594	.593
100	593	592	592	592	.592	.592	.592

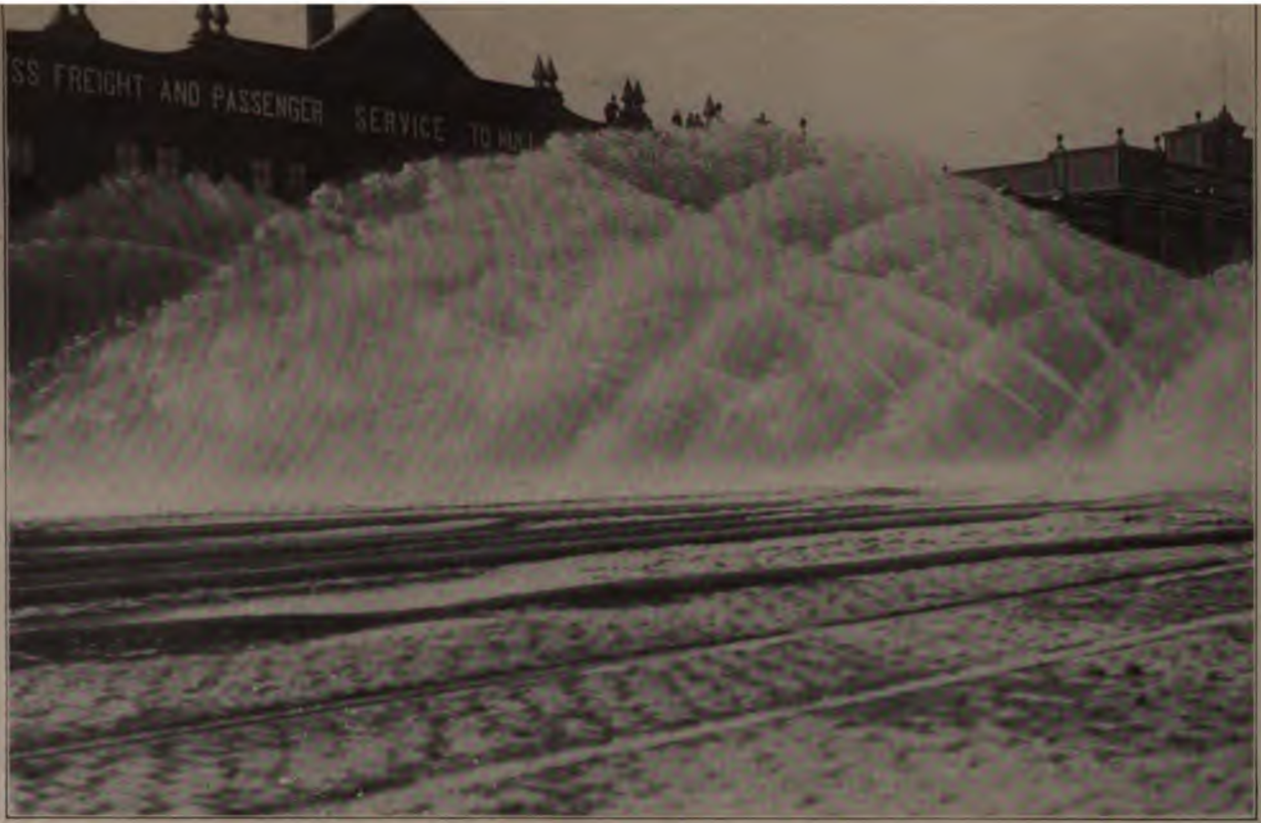
amount flowing past any other point, the velocity must be greatest where the stream is smallest. The value of V as found by the equation just given is the maximum velocity, *i.e.*, the velocity at this point of greatest contraction. The discharge from any nozzle or other orifice is equal to the product of the area of cross section and the velocity of the issuing stream *both taken at the same point.* If A represents the area of the orifice and C_c the coefficient of contraction then AC_c will be the area of one section of the stream where the velocity V is taken. Therefore, the theoretical discharge is

$$\text{discharge} = V(AC_c)$$
$$= AC_c\sqrt{2gH}$$

Putting in the coefficients to obtain actual values, we have

$$\text{discharge} = C_v\sqrt{2gH}\,(AC_c)$$
$$= (C_vC_c)(A\sqrt{2gH})$$

The product of the coefficient of velocity and the coefficient of contraction (C_vC_c) is called the *coefficient of discharge* and will be represented by C_d. In accurate work the value of this coefficient C_d should be taken from a table based on actual observation and experi-



HIGH PRESSURE SERVICE IN ACTION ON NEW YORK CITY WATER FRONT

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ASTOR, LENOX AND
TILDEN FOUNDATIONS

TABLE X

Reduction in Head (H) for Hose Stream of Given Velocity (V)]

per nd	H Feet	V Feet per Second	H Feet	V Feet per Second	H Feet	V Feet per Second	H Feet
	0.06	4	0.25	6	0.56	8	0.99
5	0.097	4.5	0.31	6.5	0.65	8.5	1.12
	0.14	5	0.39	7	0.76	9	1.26
5	0.19	5.5	0.48	7.5	0.87	9.5	1.40

Table IX. When a table is not used, take an average value .61.
ressure Transformed to Velocity. We have seen that every of water in the tank and pipes has at any point a certain it of potential energy which we have expressed as H, then H height of water above the given point, or the pressure head in We have seen further that as water issues from an orifice of stem a certain amount of the pressure or potential energy es kinetic energy or velocity head, each stream reducing the re throughout the system and consequently the height to the water can rise.

he amount that each stream reduces the pressure can be com- from the equation page 271, when the velocity of the issuing is known. Table X is computed from this equation.

riction Loss. In the foregoing discussion we have neglected ses of energy due to the curvature of the pipes, to the changes ir sizes, and to the friction of the moving water against the e of the pipes. This is called "skin friction" and the loss from rmed "frictional head." This friction loss is much greater than ue to any other cause and is influenced by the velocity of the and the size of the pipes and the condition of their surfaces. ast factor is evidently so variable that no exact law or formula present the loss in every case. The expression given below, is derived from Chezy's formula, is the best suited to our nd from it the loss for any particular case may be found.

$$h=\frac{4V^2l\left((x+\frac{y}{d}\right)}{d}$$

TABLE XI—Discharge, Friction Head, and Velocity of Flow Through Smooth Pipes Such as Cast Iron

Discharge, Gallons per Minute	¾-inch Pipe		1-inch Pipe		1½-inch Pipe		2-inch Pipe		2½-inch Pipe		3-inch Pipe		4-inch Pipe	
	Loss of Head, Feet per 100 Feet	Velocity, Feet per Second	Loss of Head, Feet per 100 Feet	Velocity, Feet per Second	Loss of Head, Feet per 100 Feet	Velocity, Feet per Second	Loss of Head, Feet per 100 Feet	Velocity, Feet per Second	Loss of Head, Feet per 100 Feet	Velocity, Feet per Second	Loss of Head, Feet per 100 Feet	Velocity, Feet per Second	Loss of Head, Feet per 1,000 Ft.	Velocity, Feet per Second
1	0.5	0.72	0.02	0.41	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2	2.0	1.4	0.6	0.82	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	4.0	2.2	1.1	1.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	7.2	2.9	1.8	1.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5	11.0	3.6	2.6	2.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6	15.0	4.3	3.6	2.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	20.4	5.1	4.8	2.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	25.5	5.8	6.2	3.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	32.0	6.5	7.7	3.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	39.0	7.2	9.4	4.1	1.1	1.8	4	1.0	0.1	0.65	0.05	0.45	.....	.....
12	.....	.....	13.0	1.9	1.6	2.2	.....	.....	.....	.....	.....	.....	.....	.....
14	.....	.....	17.1	5.7	2.2	2.5	.....	.....	.....	.....	.....	.....	.....	.....
16	.....	.....	21.8	6.5	2.8	2.9	.....	.....	.....	.....	.....	.....	.....	.....
18	.....	.....	27.1	7.3	3.5	3.3	.....	.....	.....	.....	.....	.....	.....	.....
20	.....	.....	33.0	8.2	4.3	3.6	1.2	2.0	0.4	1.3	0.2	0.90	.....	.....
30	.....	.....	.....	.....	9.5	5.4	2.4	3.1	0.8	1.9	0.4	1.4	.....	.....
40	.....	.....	.....	.....	16.0	7.2	4.0	4.1	1.4	2.6	0.7	1.8	.....	.....
50	.....	.....	.....	.....	21.0	9.1	6.1	5.1	2.1	3.3	1.0	2.3	2.3	1.3
60	.....	.....	.....	.....	34.0	10.9	8.6	6.1	2.9	3.9	1.4	2.7	.....	.....
70	.....	.....	.....	.....	45.0	12.7	11.5	7.1	3.9	4.6	1.8	3.2	.....	.....
75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.2	1.9
80	.....	.....	.....	.....	.....	.....	14.8	8.2	5.0	5.2	2.3	3.6	.....	.....
90	.....	.....	.....	.....	.....	.....	18.4	9.2	6.3	5.9	2.8	4.1	.....	.....
100	.....	.....	.....	.....	.....	.....	22.2	10.2	7.7	6.5	3.4	4.5	8.7	2.5
120	.....	.....	.....	.....	.....	.....	.....	.....	10.8	7.8	4.8	5.4	.....	.....
125	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13.1	3.2
140	.....	.....	.....	.....	.....	.....	.....	.....	14.3	9.1	6.3	6.3	18.3	3.8
150	.....	.....	.....	.....	.....	.....	.....	.....	18.3	10.4	8.0	7.2	.....	.....
160	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	21.3	4.5
175	.....	.....	.....	.....	.....	.....	.....	.....	22.7	11.8	9.9	8.1	.....	.....
180	.....	.....	.....	.....	.....	.....	.....	.....	27.5	13.1	12.0	9.0	31.0	5.1
200	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18.0	11.3	40.5	6.4
250	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	25.0	13.6	65.0	7.7
300	.....	.....												

200	4.2	2.3	1.1	1.3	.35	.82	.14	.57	.....	.....	.....	.....	.....	.....	.....	.....
250	6.3	2.8	1.6	1.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
300	8.9	3.4	2.2	1.9	.73	1.2	.30	.85	.....	.....	.....	.....	.....	.....	.....	.....
350	11.9	4.0	2.9	2.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
400	15.1	4.5	3.7	2.6	1.24	1.6	.51	1.1	.....	.....	.....	.....	.....	.....	.....	.....
450	18.7	5.1	4.6	3.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
500	22.7	5.7	5.6	3.2	1.87	2.0	.78	1.4	.18	.80	.....	.....	.....	.....	.....	.....
600	31.8	6.8	7.9	3.8	2.6	2.4	1.10	1.7	.26	.96	.....	.....	.....	.....	.....	.....
700	42.2	7.9	10.5	4.5	3.5	2.9	1.45	2.0	.34	1.1	.....	.....	.....	.....	.....	.....
800	54.0	9.1	13.4	5.1	4.4	3.3	1.82	2.3	.43	1.3	.....	.....	.....	.....	.....	.....
900	.....	.....	16.6	5.8	5.5	3.7	2.3	2.6	.54	1.4	.....	.....	.....	.....	.....	.....
1000	.....	.....	20.2	6.4	6.7	4.1	2.8	2.8	.66	1.6	.23	1.0	.08	.71		
1100	.....	.....	24.1	7.0	8.0	4.5	3.3	3.1	.78	1.8	.....	.....	.....	.....		
1200	.....	.....	.....	.....	9.4	4.9	3.9	3.4	.92	1.9	.32	1.2	.12	.85		
1300	.....	.....	.....	.....	10.9	5.3	4.5	3.7	1.06	2.1	.....	.....	.....	.....		
1400	.....	.....	.....	.....	12.6	5.7	5.1	4.0	1.22	2.2	.42	1.4	.16	.99		
1500	.....	.....	.....	.....	.....	.....	5.8	4.2	1.38	2.4	.....	.....	.....	.....		
1600	.....	.....	.....	.....	.....	.....	6.5	4.5	1.55	2.6	.52	1.6	.20	1.1		
1700	.....	.....	.....	.....	.....	.....	7.3	4.8	1.74	2.7	.....	.....	.....	.....		
1800	.....	.....	.....	.....	.....	.....	8.1	5.1	1.93	2.9	.64	1.8	.25	1.3		
1900	.....	.....	.....	.....	.....	.....	9.0	5.4	2.1	3.0	.....	.....	.....	.....		
2000	.....	.....	.....	.....	.....	.....	9.9	5.7	2.3	3.2	.77	2.0	.31	1.4		
2200	.....	.....	.....	.....	.....	.....	11.7	6.2	2.8	3.5	.92	2.2	.37	1.6		
2400	.....	.....	.....	.....	.....	.....	.....	.....	3.3	3.8	1.08	2.5	.43	1.7		
2600	.....	.....	.....	.....	.....	.....	.....	.....	3.8	4.2	1.25	2.7	.50	1.8		
2800	.....	.....	.....	.....	.....	.....	.....	.....	4.4	4.5	1.43	2.9	.58	2.0		
3000	.....	.....	.....	.....	.....	.....	.....	.....	5.0	4.8	1.62	3.1	.66	2.1		
3200	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.82	3.3	.74	2.3		
3400	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.04	3.5	.83	2.4		
3500	.....	.....	.....	.....	.....	.....	.....	.....	6.6	5.6	.....	.....	.....	.....		
3600	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.27	3.7	.92	2.5		
3800	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.51	3.9	1.02	2.7		
4000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.76	4.1	1.12	2.8		
4500	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.43	4.6	1.39	3.2		
5000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.16	5.1	1.68	3.5		

in which h is loss of head, v is velocity, l distance, and d diameter of pipe. Values of x and y are taken from Darcy's experiments on small pipes. In considering new cast-iron pipe $x = .00007726$ and $y = .00000647$, while for corroded pipes $x = .0001545$ and $y = .00001294$.

In pipes of the same size and in the same state of corrosion the frictional head increases in proportion to the square of the velocity of the water. Table XI gives the discharge, friction head, and velocity of flow through smooth pipes of different sizes.

Siamesing Hose. When a water supply is being investigated for fire purposes the indication of a high hydrant pressure at a given place is not sufficient assurance that the hydrant will give good fire service there; for it must be remembered that a few hose streams

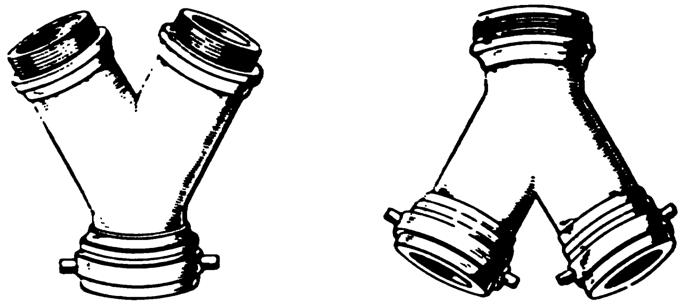

Fig. 175. Different Forms of Siamese Coupling

operating simultaneously at any point will so increase the velocity of the water in the mains that the loss of head from friction, in addition to the small loss due to the use of more than one stream from the system, and other minor losses will become very great. If the reservoir is small or distant from the town so that the water must pass through long lines of pipe, the hydrant pressure at times of greatest need may become too low to supply hose streams and unless steam fire engines are at hand to supply pressure, very little water can be gotten onto the fire.

Pressure head may be saved by siamesing hose, that is, two lines of hose may lead from the steamer and fifty or more feet back of the nozzle be united by a siamese coupling, Fig. 175. The reason for this is evident. When a given amount of water is forced through two lines of hose instead of one, the velocity is but half as great and consequently the friction loss is much smaller.

TABLE XII

Relative Discharge Capacity of Pipe

(J. T. FANNING)

Inside Diameter of Pipe	14 inches	12 inches	10 inches	8 inches	6 inches	4 inches
14 inches	1.00	1.47	2.32	4.05	8.32	22.94
12 inches	....	1.00	1.57	2.75	5.65	15.60
10 inches	....	....	1.00	1.74	3.58	9.88
8 inches	....	....	....	1.00	2.05	5.66
6 inches	....	....	....	....	1.00	2.75
4 inches	....	....	....	....	....	1.00

Carrying Capacity of Pipe. Since the larger the pipe the smaller the loss by friction, the carrying capacity of pipes of different sizes increases very rapidly as the diameter increases. The carrying capacity of pipes is approximately proportional to the square root of the fifth power of the diameter. Thus the ratio of the capacity of a 3-inch to that of a 6-inch pipe is $\sqrt{3^5}:\sqrt{6^5}$ or 15.5:88.

Table XII shows the relative capacity of pipe.

Siphon. Up to this point we have neglected air pressure. There are, however, certain devices for carrying water from one place to another, the operation of which depends upon this pressure. Mention has already been made of the siphon as a means sometimes employed for supplying water to a place beyond a rise above the hydraulic grade line.

A siphon consists of a bent tube such as $ABCD$ in Fig. 176, one end of which is longer than the other. This tube is filled with liquid and the short end immersed in liquid. The pressure forcing the water up into the tube is the pressure of the air, which is about fifteen pounds to the square inch, minus the weight of a column of water BC. The pressure forcing the water up the tube at D is the pressure of the air minus the column of water CD. Since CD is longer than BC the pressure at A is the greater and the water will flow out at D.

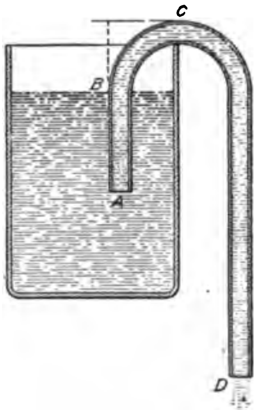

Fig. 176. Siphon

Water Barometer. The water barometer also depends upon air pressure. (See Practical Physics Part I.) If the end of a long tube be immersed in water, the water will stand but a trifle higher than that outside, this slight difference being due to capillary attraction. If, however, the air be pumped out of the tube and the top tightly sealed the water, relieved of all air pressure inside would be forced into the tube by the continued air pressure outside until the weight of the water column inside the tube balanced the pressure of the air outside. The atmospheric pressure of fifteen pounds to the square inch will support a column of water of one square inch cross section and thirty-four feet high. The operation of the majority of pumps depends upon this fact—that water will rise in a vacuum.

Water Hammer. When a column of water in motion is suddenly checked by the closing of a valve, by the pressure of a pump's plunger, or by any other force, a pressure is developed which is very much greater than the static pressure. This pressure, called *water hammer*, is often sufficient to burst pipes, the amount of pressure depending upon the length of the pipe, the velocity of flow, and the rapidity with which it is stopped. In designing pipe distributing systems and pumps, this force must be considered and air chambers or relief valves provided to take up the shock.

SOURCES AND COLLECTIONS OF WATER SUPPLY

Sources. Rain and snow are the primary sources of all water supply. The water percolates into the ground until it reaches an impenetrable stratum along which it flows until this stratum either directs it again to the surface or until at some low level a quantity sufficient to permeate the soil collects and overflows to the surface in springs. The water of a sufficient number of springs collecting in valleys and other land depressions produces ponds and lakes whos overflow produces rivers and streams. It is from these natural accumulations of water that the majority of cities and towns derive thei water supply.

There are many sections of country, however, where the wate accumulated on the top of the first impenetrable stratum of soil is inadequate and where lake or river water is inaccessible. By boring through this first impenetrable stratum, a second accumulation of water is reached which has percolated into the soil from regions eyond the area of the first impervious layer. Often the land formaion is similar to that in Fig. 177, so that this second water is under ressure and when the supply is tapped at some low point, the water s forced up—sometimes to a great height above ground. Such borngs are known as artesian wells and from these also the water suply for many places is secured. The quantity of water obtainable rom rivers and lakes is often greatly reduced in seasons of drought, o that localities depending upon such sources for their water supply hould have in addition an impounding reservoir of sufficient capacity o supply the maximum demands for fire and domestic purposes in he season of drought. When a dependable source of supply has been letermined upon, then the best means of distribution must be lecided.

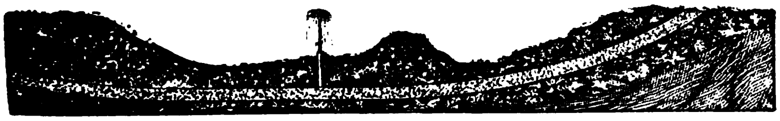

Fig. 177. Formation of Strata Giving Artesian Well

Distribution. *Natural Head.* Rarely is a place so fortunate as to have its supply near enough and, at the same time, elevated to a sufficient height for it to flow directly into the distributing reservoir and pipes. Frequently, however, there is a point of land near by, elevated 200 feet or more above the general level of the town, and wherever such is the case, none but a *gravity system* should be used, the distributing reservoir being built on this elevation. It is best to guard against the possibility of a conflagration and to make ample allowance for a reasonable growth of the town by building this reservoir large enough to hold water enough for several days' domestic consumption and over and above this a good reserve for fire purposes. Sometimes, however, it has often been necessary to economize in the size of the reservoir, or the growth of the town, since its construction has been such that the capacity is sufficient for only twelve hours domestic consumption and fire draft. In such a case, if the reservoir is kept filled, it may be considered a safe allowance for the ordinary fire for, with this reserve in case of accident to the pumps supplying the reservoir repairs could be made or steam gotten up in reserve pumps before the supply is exhausted. It is not

TABLE XI—Discharge, Friction Head, and Velocity of Flow Through Smooth Pipes Such as Cast Iron

Discharge, Gallons per Minute	¾-inch Pipe		1-inch Pipe		1½-inch Pipe		2-inch Pipe		2½-inch Pipe		3-inch Pipe		4-inch Pipe	
	Loss of Head, Feet per 100 Feet	Velocity, Feet per Second	Loss of Head, Feet per 100 Feet	Velocity, Feet per Second	Loss of Head, Feet per 100 Feet	Velocity, Feet per Second	Loss of Head, Feet per 100 Feet	Velocity, Feet per Second	Loss of Head, Feet per 100 Feet	Velocity, Feet per Second	Loss of Head, Feet per 100 Feet	Velocity, Feet per Second	Loss of Head, Feet per 1,000 Ft.	Velocity, Feet per Second
1	0.5	0.72	0.02	0.41	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2	2.0	1.4	0.6	0.82	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	4.0	2.2	1.1	1.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	7.2	2.9	1.8	1.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5	11.0	3.6	2.6	2.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6	15.0	4.3	3.6	2.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	20.4	5.1	4.8	2.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	25.5	5.8	6.2	3.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	32.0	6.5	7.7	3.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	39.0	7.2	9.4	4.1	1.1	1.8	.1	1.0	0.1	0.65	0.05	0.45	.....	.....
12	.....	.....	13.0	4.9	1.6	2.2	.....	.....	.....	.....	.....	.....	.....	.....
14	.....	.....	17.1	5.7	2.2	2.5	.....	.....	.....	.....	.....	.....	.....	.....
16	.....	.....	21.8	6.5	2.8	2.9	.....	.....	.....	.....	.....	.....	.....	.....
18	.....	.....	27.1	7.3	3.5	3.3	.....	.....	.....	.....	.....	.....	.....	.....
20	.....	.....	33.0	8.2	4.3	3.6	1.2	2.0	0.4	1.3	0.2	0.90	.....	.....
30	.....	.....	.....	.....	9.5	5.4	2.4	3.1	0.8	1.9	0.4	1.4	.....	.....
40	.....	.....	.....	.....	16.0	7.2	4.0	4.1	1.4	2.6	0.7	1.8	.....	.....
50	.....	.....	.....	.....	21.0	9.1	6.1	5.1	2.1	3.3	1.0	2.3	2.3	1.3
60	.....	.....	.....	.....	34.0	10.9	8.6	6.1	2.9	3.9	1.4	2.7	.....	.....
70	.....	.....	.....	.....	45.0	12.7	11.5	7.1	3.9	4.6	1.8	3.2	.....	.....
75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.2	1.9
80	.....	.....	.....	.....	.....	.....	14.8	8.2	5.0	5.2	2.3	3.6	.....	.....
90	.....	.....	.....	.....	.....	.....	18.4	9.2	6.3	5.9	2.8	4.1	.....	.....
100	.....	.....	.....	.....	.....	.....	22.2	10.2	7.7	6.5	3.4	4.5	8.7	2.5
120	.....	.....	.....	.....	.....	.....	.....	.....	10.8	7.8	4.8	5.4	.....	.....
125	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13.1	3.2
140	.....	.....	.....	.....	.....	.....	.....	.....	14.3	9.1	6.3	6.3	18.3	3.8
150	.....	.....	.....	.....	.....	.....	.....	.....	18.3	10.4	8.0	7.2	.....	.....
160	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24.3	4.5
175	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
180	.....	.....	.....	.....	.....	.....	.....	.....	22.7	11.8	9.9	8.1	.....	.....
200	.....	.....	.....	.....	.....	.....	.....	.....	27.5	13.1	12.0	9.0	31.0	5.1
250	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18.0	11.3	46.5	6.4
											25.0	13.6	65.0	7.7

towards the end of the supply this pressure is sufficient only to fill the mains, being available for fire purposes only where there are suction stream fire engines. From this it would be seen that standpipes are seldom large enough to furnish water for fire service. The best that can be said of them is that in case of fire they can furnish water during the interval necessary to start the pumps for continuing the supply. Even this is only true in case the standpipe is kept filled; as a matter of fact, in many small places the standpipe is filled by a few hours pumping daily or on alternate days, so that the water becomes very low from the domestic draft. With the engineer and the fires ready only at intervals, the supply is so unreliable as to be counted worthless for fire service.

Aside from these faults of insufficient supply and pressure, the standpipe itself is so liable to accident that it can be considered of no great value in a case where absolute dependability is of great importance. Besides the tremendous weight of the water which the tank and the trestle have to support, they have also to resist the varying pressure of the wind. If steel or iron form a part of the structure, as is nearly always the case, great care is necessary to keep every part, especially the angles and joints, thoroughly painted to prevent weakening by corrosion. Iron and steel expand and contract with the changes of temperature, and either extreme heat or extreme cold may seriously weaken the structure. To reduce friction loss it is necessary to have the standpipe near the town, which increases the danger of its being injured by a conflagration or an adjacent fire. But the most serious danger in winter is probably that of ice forming on the surface of the water in the tank. When the water is drawn down there is left suspended a cake of ice which is exceedingly likely to fall. The force of this great weight falling 20 to 30 feet to the surface of the water is tremendous and many standpipes are weakened or broken by such a shock.

"Holly System." Another method of distribution is the *"Holly system"* or the so-called *"direct pressure"* system of pumping the water directly into the distributing mains. The efficiency of this method is proportional to the pump's ability to respond to all variations in consumption and to the instant demands for fire purposes. When this system is used, it is necessary that the pumping station receive the alarm of fire so that the pressure can be increased. To do this in

the shortest possible time, it should be so arranged that the fire alarm may be electrically transmitted to the pumping houses and to the fire engine house at the same time; and that there always be extra pumps and steam pressure instantly available to respond to the increased need. Such a system usually gives better results in large cities than in small communities; as in the larger places the equipment is likely to be kept in better working condition and the capacity of the pumps be made so large that the work of supplying the extra water needed in case of fire is not relatively so great a tax upon the system.

Fire Boats. Cities bordering on the water front usually have *fire boats* for the additional protection of their water front. These boats are equipped with very powerful pumps which draw from the water about them and either convert it into hose streams to fight a fire near the water's edge, or else pump it into a special main laid for the purpose of carrying this water under big pressure to congested districts of the city where values are great or buildings are of unusual height, thus securing such parts the extra protection needed. (See High Pressure systems, Fire Insurance Inspection Part V.)

Miscellaneous Systems. Numerous small villages have no system of water works and, in case of fire, depend upon *wells, pumps, ponds,* and *cisterns,* from which water can be drawn by individuals or by a hand pump fire engine operated by a volunteer fire department. From an insurance standpoint, this arrangement, due to its slowness of getting into operation, its great unreliability, and the meagerness of its water supply, receives no credit as a factor of safety, and the rate for buildings of great value or of unusual risk in such a community is high.

A factory, mill, or any plant of great value in such small communities is often built upon the edge of a pond and is provided with its own appliances for using this water in case of fire. If such a site is not available, the plant or the community may provide a *fire cistern* kept filled by flowing water or by pumps and thus have ready some supply of water for use by the local fire department.

Comparison of Methods of Distribution. In comparing these methods of distribution and ranking them according to their degree of excellence, it will be seen that the *gravity system* when the reservoir is sufficiently elevated to assure good hydrant pressure under full draft (80 pounds to the square inch or more) is the best for fire service, for in such a system the pressure is instantly and constantly available; moreover, the pressure on the distributing pipes is constant and the danger of their breaking is much less than when unusual pressures are suddenly used. If such a system is not possible, then the best provision is to have some ready stored supply such as in a *reservoir* or *standpipe*, from which steam fire engines can draw until the pumps can be made ready to give direct pressure. If conditions eliminate the possibility of either of these systems, then *direct pumping* must be used.

The pumping machinery should at least be in duplicate, and even in triplicate would be safer. Pumps operated by water power are more reliable than those operated by steam, and in rating direct pressure systems the Universal Schedule makes the greatest allowance for duplicate pumps operated by water power and smallest allowance for pumps not in duplicate and operated by steam.

PUMPS

Principle of Action. A pump is a machine designed to move liquids from one position to another. In a very large percentage of cases the water supply for fire service depends at some point upon the efficiency and reliability of certain pumps, and, therefore, in order for an inspector to pass intelligent judgment on such supply it is necessary for him to understand the action of the pumps so that he can make an examination of them according to certain accepted standards.

On page 278 is explained the reason for water rising in a vacuum. The majority of pumps are designed to make use of this fact. One end of a pipe is immersed in water and by means of some displacement device acting in a chamber, a more or less perfect vacuum is created in the pipe, thus causing the water to rise. Furthermore, we have seen, that at sea level under ordinary conditions of temperature, water would rise theoretically thirty-four feet if the vacuum were perfect. But ordinary pumping machinery, on account of leakage of valves and joints, does not produce a perfect vacuum, and this fact, in addition to the loss of head from friction (especially when the water has to be drawn a horizontal distance in addition to its lift) and the decrease of air pressure at high altitudes, all tend to decrease the actual height to which water will rise. From twenty to twenty-

TABLE XIII

Maximum Suction Lift at Various Distances Above Sea Level*

Height Above Sea Level in Feet	Height of Lift		Height Above Sea Level in Feet	Height of Lift	
	Pounds	Feet		Pounds	Feet
0	14.7	33.9	2,000	13.7	31.6
100	14.6	33.8	2,500	13.4	31.0
200	14.6	33.7	3,000	13.2	30.4
300	14.5	33.6	3,500	13.0	29.9
400	14.5	33.5	4,000	12.7	29.4
500	14.4	33.3	4,500	12.5	28.9
600	14.4	33.2	5,000	12.3	28.3
700	14.3	33.1	6,000	11.8	27.3
800	14.3	32.0	7,000	11.4	26.3
900	14.2	32.9	8,000	11.0	25.4
1,000	14.2	32.7	9,000	10.6	24.5
1,250	14.1	32.4	10,000	10.2	23.6
1,500	13.9	32.1			

*The heights given are for a perfect vacuum. In practice, pumps will ordinarily lift water about eight-tenths the height given.

eight feet may be considered a good height for suction lift at sea level with good pumps. A corresponding correction must be made in the values given in Table XIII when they are applied to actual practice.

Intake Wells. When it is necessary to have the pump at a distance from the source of supply, it is good practice instead of bringing the suction pipe a long horizontal distance, to provide an intake well near the pump. Such wells are fed by the water flowing from the source through a tiled pipe extending and slanting from the source to the well.

According to the method used for forcing the water farther on through the system, pumps are classified as reciprocating (piston or plunger), rotary, centrifugal, and screw. Practically all pumps used for municipal supply purposes or for fire service, unless they are fed by water under pressure, use this suction method of filling their cylinders.

Reciprocating Pumps. A reciprocating pump, as its name indicates, consists essentially of a piston or plunger moving back and forth in a cylinder or chamber. Fig. 178 shows two methods of operation of a simple form of piston force pump, the piston acting vertically in the first and horizontally in the second. The piston by with-wing creates a vacuum and the water rises through the suction e and valve *B;* on the reverse stroke valve *B* is closed and valve *C*

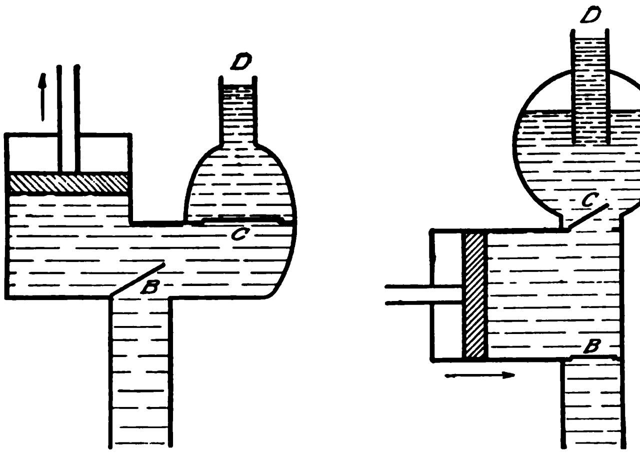

Fig. 178. Two Methods of Operating a Piston Force Pump

opened by the pressure of the water, which is then forced up ough the discharge pipe *D*.

In pumps of this kind it ecessary that the cylinder carefully bored, and the ton accurately fitted and ll packed to prevent loss force by friction and by kage of the water past the ton—"slip," as it is called. cause of the difficulty of intaining a tight piston, the inger type is more often used large pumping machinery. e plunger, which is a large aft of metal, Fig. 179, avels in a short stuffing box, d by alternately entering and ithdrawing from the chamers of the pump creates sucon and pressure through the peration of the valve *V*.

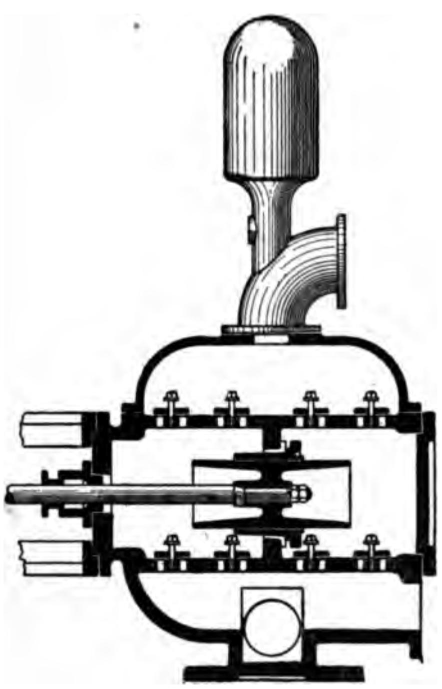

Fig. 179. Section of Plunger Pump

Double Acting Pumps. When the piston or plunger produces both suction and pressure on each stroke, it is called "double acting," Fig. 180, and such pumps are further classified according to

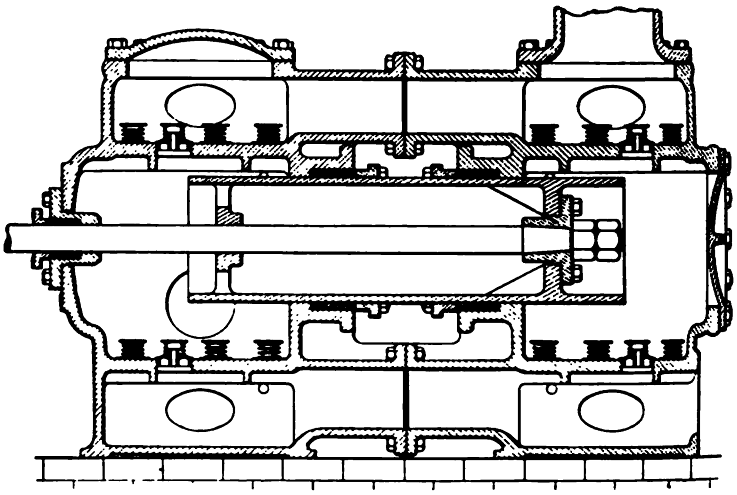

Fig. 180. Section of Double Acting Plunger Pump

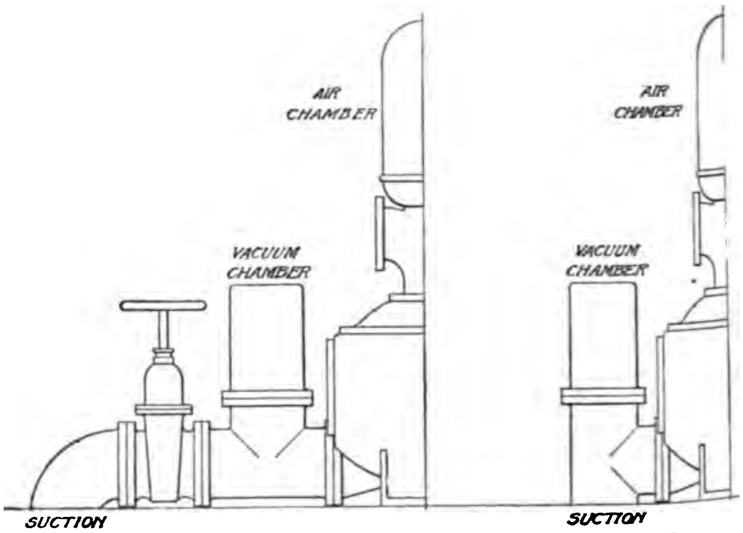

Fig. 181. Diagram Showing Location of Vacuum Chamber in Piping System

the manner in which they are packed, as "outside center packed," "inside packed," etc.

In double acting pumps the flow from the discharge pipe is more dy than in the single acting, and the addition of an air chamber t *D* in the right hand diagram of Fig. 178, makes it even more so, at the same time provides a cushion of air to receive the shock he intermittent admissions to the discharge pipe. The force of water entering the chamber compresses the air at the top and in interval between strokes this compressed air forces the water the discharge pipe thus making the flow continuous. The addi- of a vacuum chamber on the suction pipe serves to take up the k due to irregularities of the flow here. Fig 181 shows the roved position of these chambers.

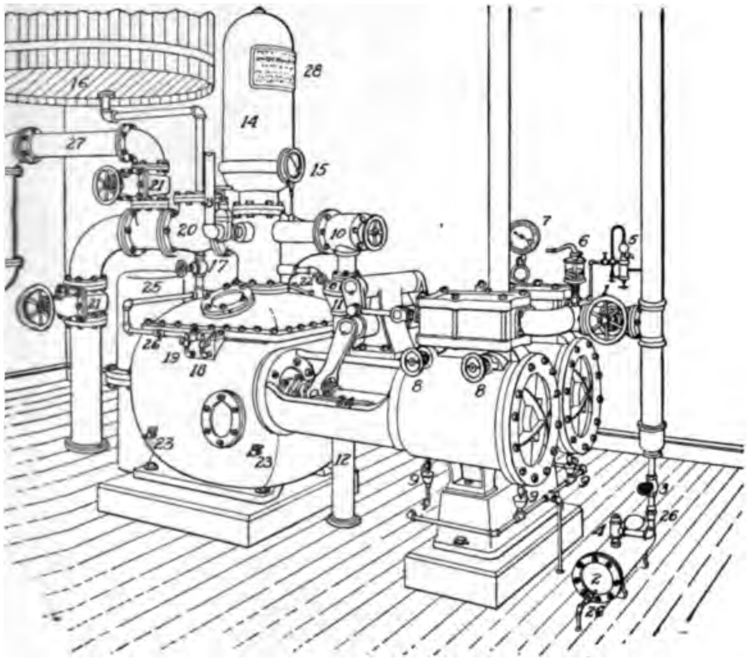

Fig. 182. Perspective Drawing of Duplex Plunger Pump with Auxiliary Piping

Duplex and Triplex Pumps. When the length of the suction and the force lift are equal, the force required to move the plunger piston in one direction is the same as that required to move it in e other. In most cases, however, the lift is much greater than the ction. To reduce the shock and the loss of power from these unequal pressures, duplex and triplex pumps have been designed which have respectively two and three cylinders, each with its separate equipment of valves, plungers, etc., working side by side, and each operating in the same suction and discharge pipe. In the duplex pump, Fig. 182, while one plunger is forcing, the other is producing suction. In the triplex pump the three plungers are driven from a shaft by three cranks or eccentrics, set at angles, of 120° to each other. Thus the amount of power required to operate either of these pumps does not constantly vary as it does when but one cylinder is used.

Index of Parts, Fig. 182*

1. *Throttle Valve.* Should be a globe valve.
2. *Steam Trap.* This is shown connected at base of steam pipe and should always be connected as shown on cut in order that condensed steam may be prevented from entering the cylinders.
3. *Globe Valve.* To shut off the steam trap temporarily for repairs.
4. *Pocket.* For holding a wire cage for catching chips and preventing foreign substances from entering the trap. This wire cage can be removed and cleaned without disconnecting the trap.
5. *Sight-Feed Lubricator.* This should be connected at the point shown.
6. *Hand Oil Pump.* Glass body, capacity one pint, for generously lubricating steam chests and cylinders when starting.
7. *Duplex Spring Steam Gauge on Steam Chest.* It should be connected directly into the steam chest in order that the pressure under which the pump is operating can be determined. If steam gauge is desired back of the throttle valve, another one should be provided and placed anywhere on main steam pipe to suit the convenience of the case.
8. *Hand Wheels.* Operating cushion valves to regulate the length of stroke of pump.
9. *Drip Cocks and Open Cups.* This arrangement should be made strictly in accordance with the sketch in order that there may be no steam connection from the drip of steam cylinders that will allow the pressure to accumulate or pass around to the end of a cylinder when exhausting. Care should be taken that the drip pipe does not connect to the steam trap. It should convey the condensed steam to some open drain preferably where it can be seen.
10. *Relief Valve.* Must conform strictly with the Underwriter pump specifications.
11. *Open Cone.* For observation of operation of relief valve.
12. *Waste Pipe from Relief Valve.* This should be at least one size larger than the relief valve on pump, should have a cone "11" and should be carried to some point where the water can flow freely without backing up into the pump house.

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*Where fire pump is supplied from storage reservoir or tank, the drain pipe from relief valve must be arranged to return water to the reservoir. This plan will save water which otherwise might be lost through relief valve during fire or test.

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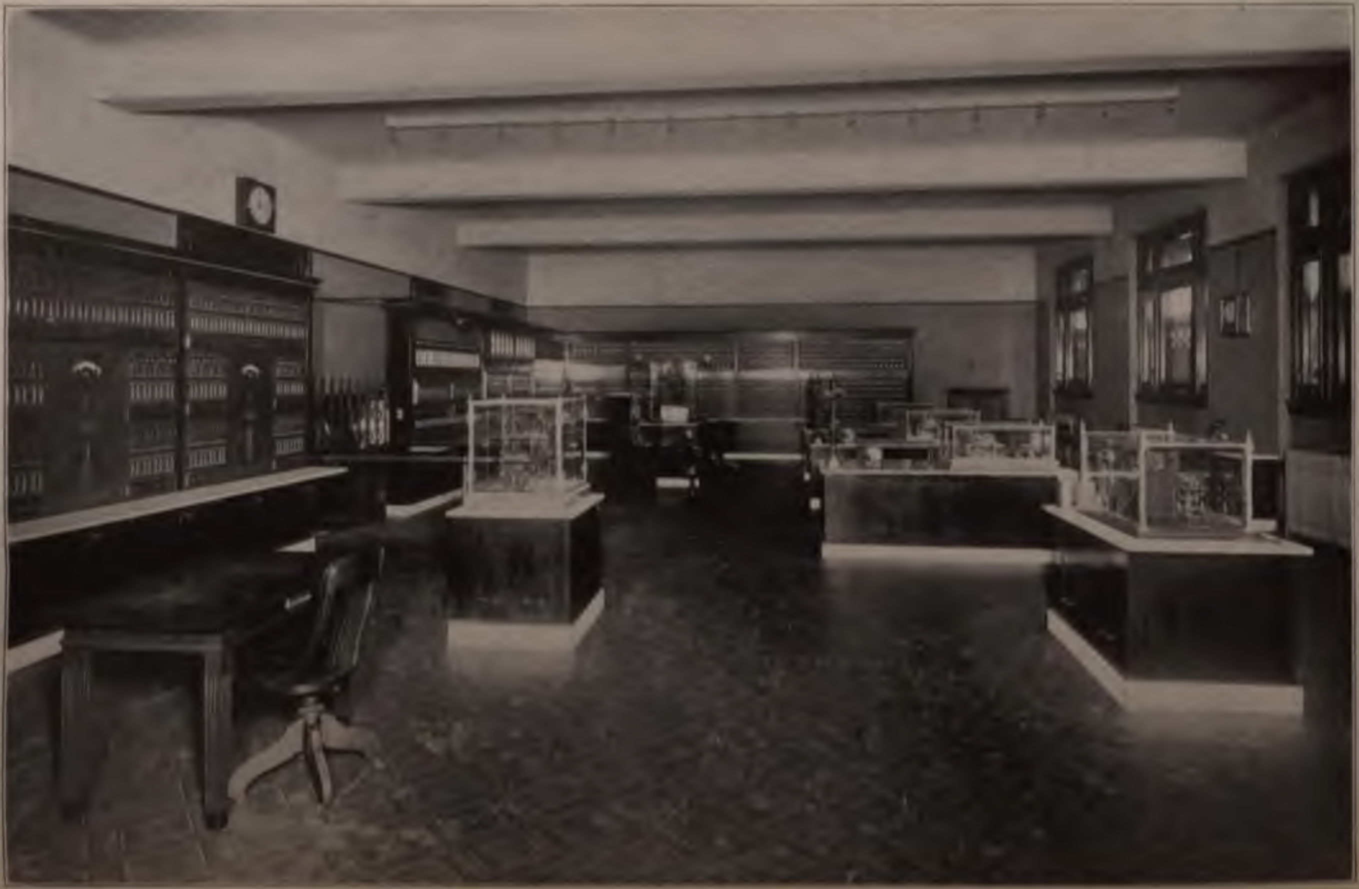
ASTOR, LENOX AND
TILDEN FOUNDATIONS.



INTERIOR OF THE NEWARK, NEW JERSEY, FIRE ALARM CENTRAL OFFICE

Courtesy Gamewell Fire Alarm Telegraph Company, New York

13. *Boiler Feed.* This should have a horizontal check valve near the pump in the overhead pipe.
14. *Air Chamber.*
15. *Duplex Spring Water-Pressure Gauge.* This gauge should be located and connected as shown on cut.
16. *Priming Tank.* Capacity of priming tank should be one-half of the capacity of the pump for one minute.
17. *Priming Valve.* The pipe connection from priming tank to pump in which this valve is located should not be less than 2 inches.
18. *Priming Device.*
19. *Priming Vents.*
20. *Horizontal Check Valve.* This valve should be of the swinging pattern, making straight water-way without obstruction.
21. *Indicator Gate Valves.* These should be of the target indicator pattern—not outside screw and yoke.
22. *Air Vent.* Brass gate-valve and brass pipe, relieving the air cushion in force chamber of pump. Size should be 1" for 500 gal. and 750 gal. pumps and 1¼" for 1,000 gal. and 1,500 gal. pumps.
23. *Lever Handle Drip Cocks.* For draining the pump below the valves in case of repairs or to prevent freezing.
24. *Stroke Gauge.* This should be of brass, with plainly marked lines for the full stroke of the pump and with a fixed index on the piston rod so that the pump stroke can be noted.
25. *Suction Air Chamber.* This should be of size and in accordance with the specifications of Underwriter pump.
26. *Unions.* For disconnecting and removing any of the various parts in which they are placed.
27. *3-Way Wall Hydrant Connections.*
28. *Name Plate.*

Direct Action. Reciprocating pumps are most often directly operated by steam; that is, the steam piston and the water piston or plunger are attached to opposite ends of the same rod. The steam piston is moved by steam entering the steam cylinder through valves first at one end and then at the other. In *high pressure* engines, the steam at full pressure follows the piston during the entire stroke; in *compound engines,* however, which are designed with two steam cylinders, steam at full pressure is admitted to the first cylinder, acts upon the piston during the first part of the stroke, and is then exhausted into a second steam cylinder where it expands and produces force for finishing the stroke. To make the stroke throughout its length and to cover the interval when the operating force is transferred from one cylinder to another, these engines require a fly-wheel or "compensator."

Clearance. Some provision is necessary to regulate the length of the stroke and to prevent the water plunger or the steam piston from striking the end of the cylinder. This is called *clearance* and is best regulated by steam cushion valves which are arranged to retain in the steam cylinder a certain amount of steam as a cushion, thus limiting the travel of the piston to the required distance. In the water cylinder the clearance is determined by the size of the casing beyond the possible length of stroke of the piston or plunger.

Steam Valves. Steam for moving the piston comes from the boiler through pipes into a steam chest in which a slide valve alternately opens and closes the steam and exhaust ports in each end of the cylinder. These valves, for which there are many designs, depend upon the sliding of the upper section back and forth over a series of openings, and their parts are so designed that faces of this moving section close certain steam ports and exhausts, and open others at the proper time. Fig. 183 shows a typical slide valve and its relation to the cylinder.

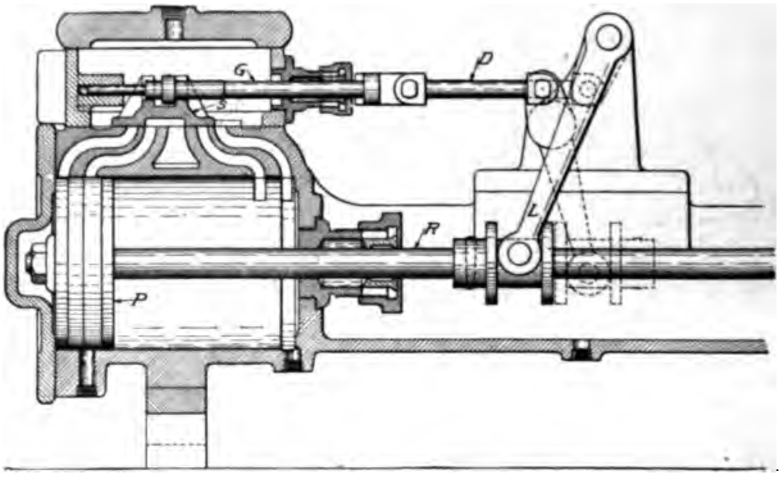


Fig. 183. Section Showing Piston and Valve Action on a Dean Duplex Pump

In the duplex pump which is the type generally used for large pumping engines and which is the only type meeting the requirements of all insurance companies, this sliding portion of the steam valve *S*, Fig. 183, is operated by a valve rod *C D* which for either side of the pump receives its backward and forward motion from the main piston rod of the opposite side. For example, by the motion of the piston *P*, Fig. 183, the rod *R* moves the arm *L* which in turn moves the valve rod of the other member of the duplex pump. This is also shown in Fig. 182.

Rotary Pumps. A rotary pump consists of two revolving pistons rotating in opposite directions within the pump's casing. These pistons are always in contact with each other and each is constantly tangent to the pump's casing, so that when this chamber is filled with water—that is, when the pump is primed—the rotation of these impellers carries the water away from the suction pipe and forces it up the discharge pipe. This process creates a partial vacuum which causes the water to rise in the suction pipe. Rotary pumps differ principally in the design of their impellers, Fig. 184 showing some of the shapes which are used.

Rotary pumps are most often operated by being belted or connected with frictional wheels to a turbine or electric motor. They have several advantages over reciprocating pumps, one of which is the ability to operate without valves; another advantage is that none of the operating force is lost in constantly changing its direction as is the case with reciprocating pumps. However, the constant friction between the "cams" causes them to wear and leak, thus diminishing the capacity and efficiency of the pump; therefore this type is seldom selected for service requiring constant operation, such as a supply of water for municipal use. As fire pumps they are more often used, yet even in this field other types have the preference as rotary pumps attain their greatest efficiency at low pressures. On account of their portability they are sometimes used for fire engines, although for this purpose duplex steam pumps are most often used. An approved type of rotary pumps is shown in Fig. 185.

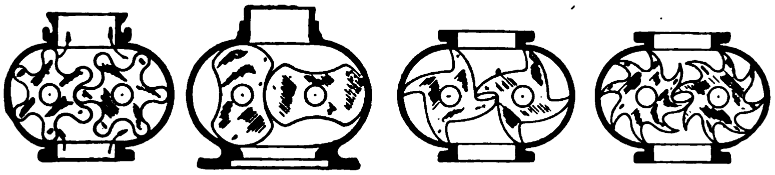


Fig. 184. Different Types of Revolving Pistons in Rotary Pumps

Centrifugal Pumps. The construction of a centrifugal pump is shown diagrammatically in Fig. 186. By applying power to the axis *A*, the wheel is made to revolve rapidly and water is drawn up through the suction pipe *S*, discharging at the axis of the wheel. The latter wit is curved vanes whirls the water around and imparts great velocity to it before it is thrown off by centrifugal force into the discharge pipe *D*, where the velocity imparted to the water produces a static pressure.

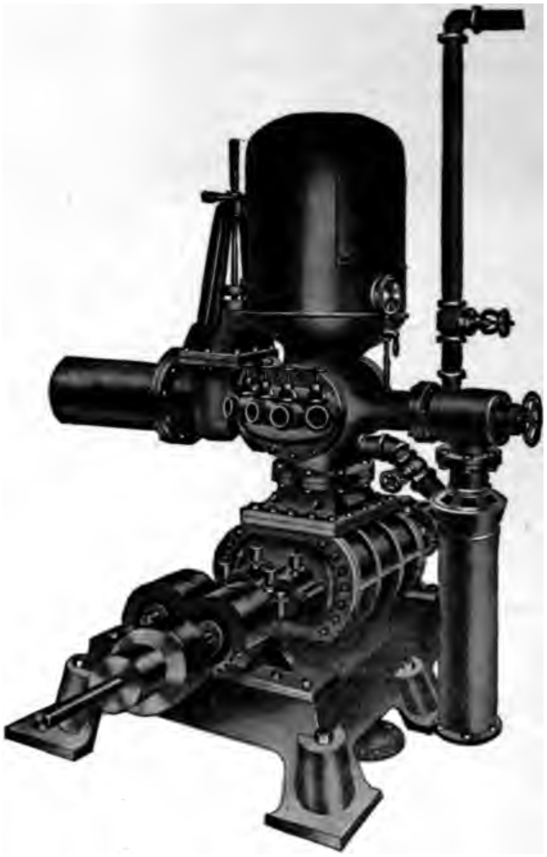


Fig. 185. Type of Rotary Pump Approved by Board of Underwriters

Courtesy of Inspection Department Associated Factory Mutual Fire Insurance Companies, Boston, Massachusetts

In some centrifugal pumps there is a diffusion chamber surrounding the revolving wheel through which the water leaving this wheel must pass before entering the discharge pipe. The size of the passage through this chamber gradually increases so as to transform the velocity head into pressure with the least possible shock.

Like the rotary pump the centrifugal pump has the advantage being able to work without valves; furthermore, it can handle uddy or dirty water for even gravel can pass through the vanes of e wheel without injuring them. Until recently they were used ıly for low pressures, but there is now being rapidly developed a *ulti-stage pump* which has a series of the revolving wheels and ıambers already described so arranged that the water leaving one acted upon by the next and the pressure is successively increased. ot long ago insurance companies looked with disfavor on the cen-ifugal pump for fire service, but it has developed and gained favor › rapidly, however, that this type was selected for the recently ıstalled Brooklyn high pressure system, Fig. 187, and many fire ›ats are now equipped with it.

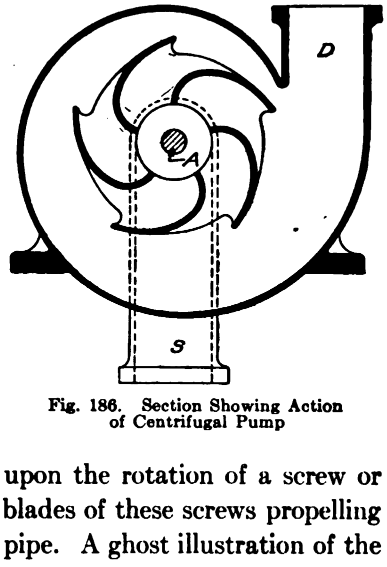


Fig. 186. Section Showing Action of Centrifugal Pump

Screw Pumps. The screw pump ıile not used simply as a fire pump, ›f interest from a fire insurance ndpoint because it is so often d in hotels, apartment houses l institutions where the pulsa-ı and consequent jar and noise dent to other types would be ectionable. Thus this pump is n used for filling roof tanks ch supply private fire protection tems such as sprinklers, stand-es, and perforated pipe lines. action of these pumps depends upon the rotation of a screw or ws within a hollow casing, the blades of these screws propelling water from suction to discharge pipe. A ghost illustration of the mby screw pump is shown in Fig. 188. There are two parallel ating shafts *B B* on the ends of which are screws so placed that threads of one fit into the grooves of the other. These screws close but not tangent either to each other or to the casing. The ter is drawn in from the suction pipe *S* at either end of the casing lding the revolving screws *v*, that is, at *M M*, and is propelled by screw threads towards the center and up through the discharge pe *D*. As the water is discharged, a partial vacuum results caus-g more water to rise in the suction pipe.

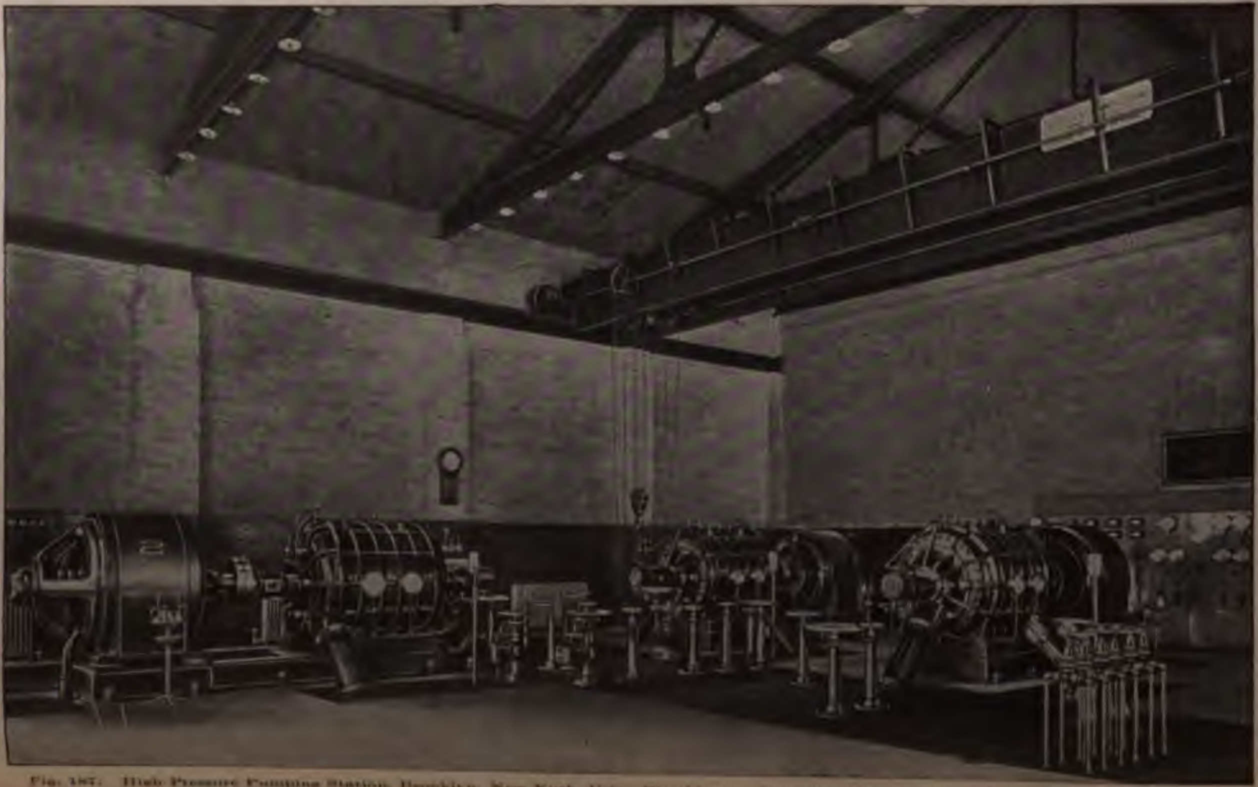


Fig. 187. High Pressure Pumping Station, Brooklyn, New York, Using Worthington Centrifugal Pumps. Three Units, Each 3,000 Gallons per Minute, 300 Pounds Pressure.

Courtesy International Steam Pump Company, *New York*

Valves. Whatever the design of the pump, the discharge and suction pipes are usually fitted with valves, so that at times when the pump is idle or running at low speed, the closing of these valves will prevent the water from dropping out of the suction pipe and the water which already has been pumped as in the case of rotary or centrifugal pumps, from returning through the pump to the source. The notable exception to this is in the case of fire pumps. Underwriters prefer that there be no valve on the suction pipe for this is liable to become clogged and in cases of emergency, reduce the amount of water that can be drawn from the source. Instead of this, provision is made for filling the suction pipe and cylinder when the pump starts by the addition of a priming tank or by attaching a small auxiliary pump.

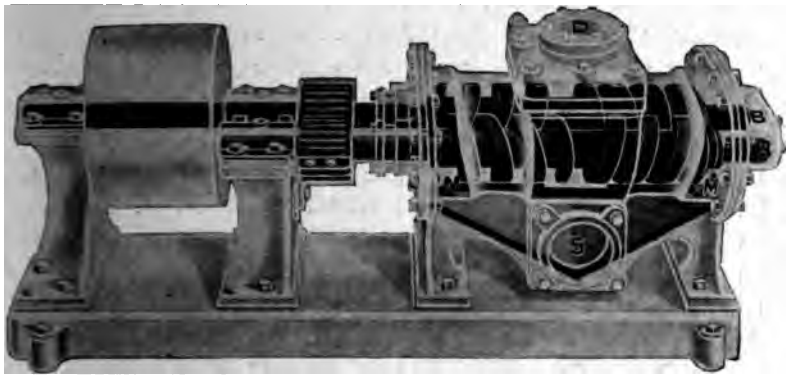


Fig. 188. Quimby Screw Pressure Pump
Courtesy William E. Quimby, New York

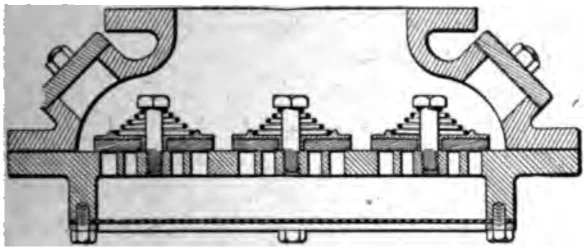


Fig. 189. Section Showing Construction of Foot Valve

A *foot valve* such as is used on the submerged end of a suction pipe is illustrated in section in Fig. 189. The discharge pipe is usually fitted with a *check valve*, Fig. 190, consisting of simply a hinged flap which, when opened, strikes against a buffer, thus limiting the angle (usually 30 to 60 degrees) at which this may swing back. If the flap were permitted to open beyond this angle it would not close promptly.

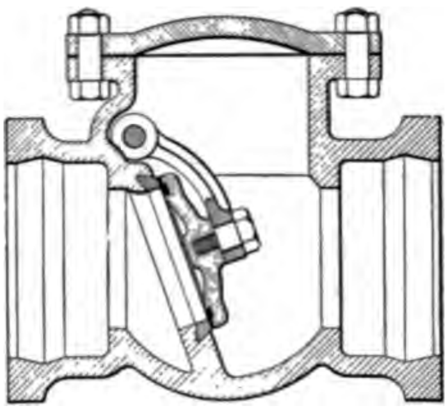


Fig. 190. Section of Typical Form of Check Valve

Besides these two valves, reciprocating pumps require the use of others to control the alternate opening and closing of the suction and discharge chambers. The uses of these valves require that they close tightly and promptly to prevent loss from leakage or slip; that they open under small pressure and have large waterways to reduce the loss of head to a minimum; and that they be placed so as to be easily reached to be repaired or replaced.

Instead of using one large valve to cover a given area it has been found best to use several small ones, grouped as shown in Fig. 189. The type of valve most generally used is illustrated in section in Fig.

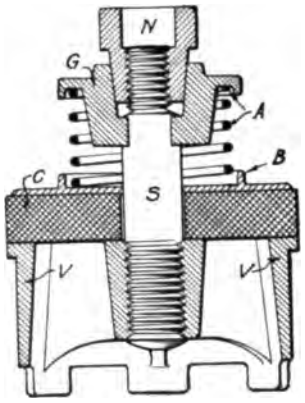


Fig. 191. Section of Water Valve Showing Method of Seating

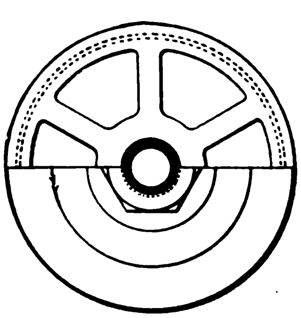


Fig. 192 Plan of Water Valve Shown in Fig. 191

191 and in plan in Fig. 192. A disk of hard rubber or metal *C*, Fig. 191, is loosely mounted on a stud. On the end of that stud is a guard *G*

and nut *N*, and in some cases, as in the valve illustrated, a spring *A* is mounted between the guard and a cap plate *B* to expedite the closing of the valve. The stud is held upright in the middle of the opening by being screwed into the center of the valve seat *V*, the latter being braced by ribs extending from the circumference of the orifice to the base of the stud as shown in upper half of Fig. 192. The valve and seat are accurately fitted to each other and the valve seat screwed or driven into position.

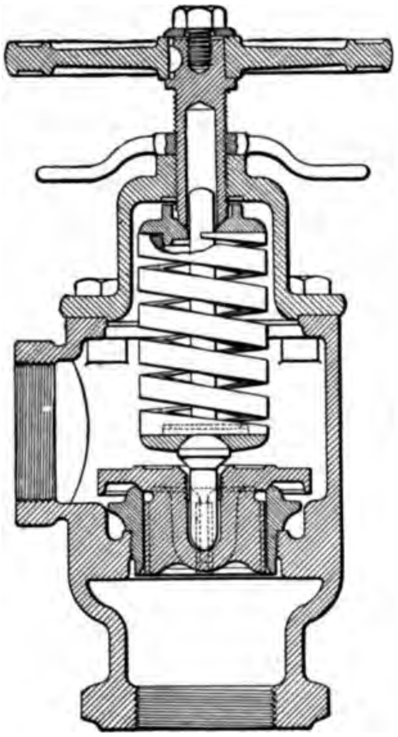


Fig. 193. Section of Relief Valve

Insurance companies specify that all fire pumps should be fitted with a *relief valve*, Fig. 193, which is so constructed that a pressure in excess of that at which the valve is set will cause it to open and allow sufficient water to escape in order to reduce the pressure to the required point again. In fire pumps this valve is usually set at 100 pounds. The preferred position for the relief valve is at the base of the air chamber, Fig. 194, whence it should extend horizontally inward and should discharge in a vertical downward direction into a funnel which in turn should discharge through a waste pipe to some point outside the pump house. Fig. 195 shows the required marking of the hand-wheel.

Fire Pump Standards. Factories, mills, and other plants of large value are usually provided with private pumping stations designed especially for fire purposes. The stock and mutual companies have agreed upon certain requirements which are accepted by the National Board of Fire Underwriters and these requirements constitute the specifications for the "National Standard Fire Pump."

Only four sizes are recognized, the 500 gallon, 750 gallon, 1,000 gallon, and the 1,500 gallon. The specifications provide in general for an especially rugged construction with unusually large pipes or passages for both steam and water and that all working parts should be of brass or bronze, thus making them rust proof and enabling the pump to start instantly after long disuse.

SPECIFICATIONS FOR NATIONAL STANDARD FIRE PUMPS

Steam Pumps. These must be duplex and the pumpmaker must guarantee that, before leaving the shop, they have been tested and found sufficiently strong to stand, with all water outlets closed, the force produced by 80 pounds steam pressure in the steam cylinder. For pumps of twelve-inch and sixteen-inch stroke the combined port area of the suction valves should be respectively 56 and 64 per cent of the plunger area. The combined outlet area of the discharge valves should be two-thirds of the suction valve area in that particular case.

The disk of rubber forming the valve must be of the best quality of medium temper hard rubber. It must not be greater than four inches in diameter nor less than three, and in no case less than five-eighths inch in thickness. Both the suction and discharge valves in one pump must be of the same size and interchangeable. They must also be double faced so as to be turned when worn. They shall be so placed that the space between two valves is not less than one-fourth the valve diameter, and the distance to the wall of the valve chamber is at least one-eighth of the diameter of the valve. To prevent valve slam, the total lift must not exceed one-half inch. The spring used to facilitate quick closing of the valve should be cylindrical and not conical in shape, and should be made of the best spring brass wire. At the top it should be held centrally by resting in a groove in the valve guard *G*, Fig. 191. At the bottom of the spring and covering the entire valve disk there must be a thin rustless metallic plate *B* made with a raised head to guide the spring at the bottom.

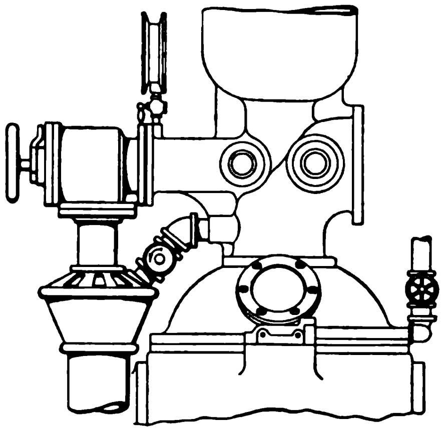


Fig. 194. Proper Location of Relief Valve in System

The spring in the suction valve should permit with a ten- to fifteen-foot lift the valve to open one-fourth inch under a force of one pound to the square inch. If water enters under a head the valve spring should be much stiffer than this to prevent water-hammer; and for this same reason the spring on the discharge valve should be three or four times as stiff as those just described.

All valve stems must be of three-fourths inch bronze, with a guard and nut. Valve seats must also be of bronze, and screwed into the valve deck on a taper thread or driven in on a smooth taper fit. The seat must then be flanged out on the under side of the deck which should be rounded over to give good bearing for this expanded part, or it may be held firmly by providing a lug opposite each rib. By either of these methods the possibility of the valve seat working loose is eliminated.

A pressure gauge of the Lane double tube spring pattern with a 5-inch case must be attached to the pump as shown at 15, Fig. 182. This gauge should be marked to read up to 240 pounds pressure, and should be marked "WATER." A relief valve, as described on page 297 and shown in Figs. 193 and 194, should be attached. This valve should be able to pass all the water discharged by the pump at full speed at any pressure up to 125 pounds.

At each end of each water cylinder there should be a brass drain cock with lever handle, and with a passageway of one-half inch. Another cock of similar construction should be provided over the upper valve deck, and an air vent should be placed in the upper cover of the water cylinder.

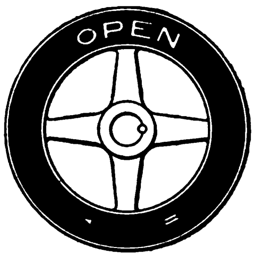


Fig. 195. Markings on Wheel of Relief Valve

Unless water is taken under a head, the pump must be provided with brass pinning pipes according to the sizes given in Table XIII. These pipes must be connected to plunger chambers and then extend to a main pipe at least 2 inches in diameter which would lead up to the pumping tank, the bottom of which must be 2 feet or more above the pump. The capacity of this tank should be about one-half the rated capacity of the pump. Each of the pinning pipes should be fitted with a two-seat controllable valve by which the water is admitted and the air let out simultaneously. Besides these parts, fire pumps should be fitted with 2½-inch hose outlets with valves, according to the number of hose streams they are to supply.

Table XIII gives dimensions for steam piston and fittings as well as for the water piston or plunger.

Steam End. The area of the exhaust steam passages at the smallest cross section must not be less than 4 per cent of the piston area, while the steam admission ports must not be less than 2½ per cent of the piston area.

The steam slide valve must be most accurately fitted, and must be steam tight when in contact with the seat of the valve.

NATIONAL STANDARD FIRE PUMP
16 x 9 x 12
CAPACITY
750 GALLONS PER MINUTE, OR
3 GOOD 1⅛-IN. SMOOTH NOZZLE
FIRE STREAMS
FULL SPEED
70 REVOLUTIONS PER MINUTE
NEVER LET STEAM GET BELOW
50 POUNDS, NIGHTS, SUNDAYS OR
AT ANY OTHER TIME

Fig. 196. Standard Pump Plate

To govern the length of the stroke, steam cushion valves regulating the amount of steam left in the cylinder at the end of each stroke should be attached to either end of the cylinder. A stroke gauge also should be securely fixed in place so that it can not get out of adjustment from the jar.

A Lane pressure gauge, as described for the water cylinder, should be attached to the throttle, marked STEAM, and scaled to indicate pressure up

TABLE XIV

Fire Pump Data (For Both Water and Steam Ends)

Nominal Capacity of Pump in Gal. per min.	Number of Hose Streams 1⅛"	Pump Sizes (in Inches)			Ratio of Piston Areas	Boiler Power Required		Steam End			Size of Vacuum Chamber (Gallons)	Size of Air Chamber (Gallons)	Diam. of Suction Pipe (Inches)	Diameter of Discharge Pipe (In.)	Diam. of Steam Pipe (Inches)	Diam. of Exhaust Pipe (Inches)
		Diameter Steam Piston	Diameter Water Piston	Length of Stroke		Horsepower	Lbs. Steam Pressure at Pumps	Thickness Steam Piston (Inches)	Diameter Piston Rod (Inches)	Diameter Valve Rods (Inches)						
500	2	14	7 7¼	12	about 4 to 1	100	40	3½	2	1	13	17	8	6	3	4
750	3	16	9	12	3 to 1	115	45	4	2¼	1⅛	18	25	10	7 or 8	3½	4
1000	4	18 18½	10 10½	12	3 to 1	150	45	4½	2⅜	1⅛	24	30	12	8	4	5
1500	6	20	12	16	2¾ to 1	200	50	5	2½	1¼	30	40	14	10	5	6

to 120 pounds. At each end of each cylinder, a drain cock, as already described for water end, is required.

Tests. Before being accepted the pump should pass satisfactorily the following test: Hose should be attached to provide outlets for the water, and the pump run at somewhat above its rated capacity. Under this test there should be no excessive vibration, or pounding, and when the cushion valves are adjusted there should be no noteworthy valve slam or water hammer.

Table XIV shows the steam pressure usually needed to produce the indicated water pressure; if an amount much in excess of this is required to produce this pressure, it is an evidence of too great internal friction.

The outlets should be nearly closed and steam admitted until the water pressure is 240 pounds. Under this pressure there should be no considerable leakage.

All outlets should be closed in order to test the relief valve, which when set at 100 pounds should be able to discharge the full rated capacity of the pump, without allowing the pressure to exceed 125 pounds.

With the outlets still closed and the safety valve set at 115 pounds, steam should be admitted to bring the water pressure up to 100 pounds. The pump will now move very slowly, according to the leakage past the plunger or piston. This leakage should not allow the pump to make more than from one-third to two double strokes a minute.

Pumps designed, built, and tested according to these specifications should have a capacity plate, Fig. 196, attached to the inboard side of the air chamber, bearing certain required data in ½-inch raised metal letters buffed off to a smooth finish or a black background.

TABLE XV

Rotary Fire Pump Data

Gallons per Minute	Number of 1½-Inch Hose Streams	Speed in Revolutions per Minute	Diam. of Suction Pipe (Inches)	Diam. of Discharge Pipe (Inches)	Size of Priming Tank (Gallons)	Approximate Width of Buckets (Inches)	Distance Between Centers (Inches)	Approximate Horsepower Required
500	2	250 to 300 revolutions per minute	6	6	200	8	7- 8	60
750	3		8	8	300	9 or 10	8- 9	90
1000	4		8	8	400	10	9-10	120
1500	6		10	10	500	12	10-12	180

Rotary Pumps. Table XV gives dimensions of the principal parts of the Underwriters Rotary Pump (see Fig. 185), which differs from the ordinary trade rotary pump in that all the parts exposed to corrosion are of bronze or some other non-corrosive metal; the water passages are larger; and these pumps are required to have several special attachments, such as a discharge casing, bolted in an upright position to the main casing, to which is to be attached a large air chamber, a spring relief valve, a water pressure gauge, hose valves similar to those already described for a steam pump, and also a starting valve to allow the air to escape when the pump is started.

After being set up the pump should be tested to make sure that it runs smoothly without slamming and that the water relief valve can pass the full discharge of the pump without allowing the pressure to rise above 125 pounds. The capacity plate of these pumps should contain certain data corresponding to that required for a steam pump.

Centrifugal Pumps. Centrifugal pumps must have not less than two, nor more than four stages.

When new, a pump should be practically tight under a test of 240 pounds water pressure. All parts exposed to the water must be of bronze. The design of the impellers must be such that the maximum width of the water passage at the periphery of the impeller shall be ⅝ inch at least, ¾ inch is preferred. The shaft must be of steel protected with a composition metal. These pumps should have hose valves and a starting valve to release air, and a Lane Water Pressure gauge as before described. One half-inch drip plugs must be provided at the lower end of the impeller chambers, to permit of draining all parts of the pump.

Centrifugal pumps should preferably take their suction under a head. If this cannot be arranged, their suction pipes should be fitted with brass foot valves. In either case a vacuum chamber with a vacuum gauge should be attached to the supply pipe.

Instead of providing a foot valve to keep the suction pipe full, a priming tank of at least 250 gallons capacity may be substituted and connected to fill the pump casing for starting, as these pumps have no lifting ability until first filled with water. Table XVI gives dimensions and important data for the standard pump.

TABLE XVI

Centrifugal Fire Pump Data

Gallons per Minute	Number of 1½-In. Hose Streams	Permissible Speeds in Revolutions per Minute	Horsepower Required	Size of Pump Span (Feet)	Section Inlet	Disc Ou
500	2	800 to 1500	64 to 60	2	6	
750	3	700 to 1400	88 to 80	3½	8	
1000	4	700 to 1400	107 to 100	3½	8	
1500	6	600 to 1200	148 to 138	4	10	1

The capacity plate and the test of these pumps is in general the sa for other types.

Steam Power for Pumps. Reciprocating pumps are most g ally driven by steam power although they may be operated by b attached by a connecting rod and crank to any form of motor tur or water wheel, or by a gas or gasoline engine. Insurance comp consider pumps operated by water power as more reliable than st driven pumps since water power is instantly available, whereas st may not be up at the time of need.

Steam Boilers. If the water supply comes from a muni system, the pumps then to be considered usually receive their op ing steam from boilers, installed for and devoted to just that pur However, in the case of private fire pumps used in factory and yards, the steam supply usually comes from the same boilers that vide the steam for moving the machinery, elevators, etc. When is the case the pipes which carry the steam for factory use shoul fitted with valves, so that in case of fire any of these pipes ma cut off and the steam devoted exclusively to the use of the fire pu

The steam boilers in use vary greatly in construction, and t choice depends largely upon the custom of the locality where are to be used; the character of the water there; the kind and the of fuel; and, of course, the amount and pressure of steam requi

The *simplest form of boiler* consists of a cylindrical shell mad riveted plates of steel. In use, this boiler is filled almost two-th full of water, the upper third of the space being left as steam space. It may be set over or within a furnace, with the fire box beneath it and the flues arranged about it to permit the heated gases to circulate about the boiler before they pass up the chimney, thus heating the water. Such a boiler is said to be "externally fired."

In many types the furnace is tubular in shape and enclosed within the boiler shell, the flues extending the full length of the boiler and heating the water from their surface. These are designated as "flue boilers" or "internally fired" boilers.

So called *tubular* or *fire tube boilers* are built with numerous tubes, usually from three to four inches in diameter, within the shell and extending the entire length of the boiler. The heated gases from the furnace pass through these tubes and heat the water.

To withstand high pressure any of the types of boilers already described require very thick shells, making the boiler heavy and cumbersome. If it becomes weakened or is carelessly handled, an explosion is likely to occur, the entire mass of heated water is relieved of the pressure, and is instantly converted into steam, thus causing great damage to adjacent property.

Such boilers furnish steady steam pressure on account of the great quantity of heated water, although they are very slow in responding to a sudden demand for extra steam, and three or four hours are required to raise steam from cold water.

To overcome these defects many so called *water tube boilers* have been constructed. In this type the water instead of being contained and heated in a large shell is contained in numerous small tubes which pass over the fire box of the furnace, and around which the hot gases circulate. The water heated in these tubes rises into a drum or separator where the steam and the water separate, after which the water passes down through other pipes and is returned again to the water tubes.

The steam pressure in these boilers fluctuates with the condition of the fires, so careful operation is necessary to secure nearly uniform pressure. This very fact, however, makes it possible to raise extra steam very quickly by driving the fires.

The amount of heated water in one place in these boilers is so small that to obtain the necessary strength the parts do not need to be unusually thick or heavy, and there is less danger of an explosion;

even if one occurs on account of a weak tube or other part, the amount of steam liberated and the damage done is comparatively small.

In localities where the water contains mineral matter, the fire boilers are best, as in these the surfaces which can become corroded or incrusted with mineral deposit are more easily reached and cleaned than the parts of the more complex tubular interior. The corrosion and mineral scale in water tube boilers is reached with difficulty and a small amount of it affects the efficiency of the boiler. If it is found advisable to use this type where water is impure, the feed water may be distilled, settled or mixed with prepared boiler compounds to reduce the deposit as much as possible.

For *fire engine* use, *boilers* should be light and able to produce steam quickly and abundantly. This is accomplished partly by providing small water space and large heating area. Cannel coal is generally used and burned with a forced draft obtained by exhausting steam up the smoke pipe. These boilers are not economical of fuel.

Engine houses are equipped with heaters which keep the boilers hot when not in use so that the fire beneath them is not lighted until the engine is called out.

Many engine boilers have a combination of fire tubes and water tubes, tubes containing water extending from the water chest down into the fire box, and fire tubes from the furnace extending upward through the water. One of the best of this type of boiler is shown in Fig. 197.

Power for Electric Pumps. *Current Source.* Rotary, centrifugal, and screw pumps are usually run by electric motors, though any other form of prime mover may be used. Any current supply to be acceptable for driving fire pumps must show proofs of its reliability. It must be able to supply power day and night every day of the year, and its record of service must show no interruption of more than one-half hour in any one year, and no more than four interruptions exceeding five minutes each. The pumping station must receive its supply of power through two different lines, preferably from two separate stations; but if necessarily from the same source these two circuits must be entirely independent of each other from the power house to the pump's motor. If *transformers* are necessary, they should be located in a fireproof vault cut off from the pump room and thoroughly ventilated to the outer air through a flue.

Wiring Specifications. At the point where the wires enter the pump house a *double throw switch* must be provided so that at any time the motor can be cut off from all sources of supply. A *circuit breaker* must also be installed and set so as to operate when the amount of current taken reaches twice the amount required properly to run the pump at normal speed, when discharging full capacity at 100

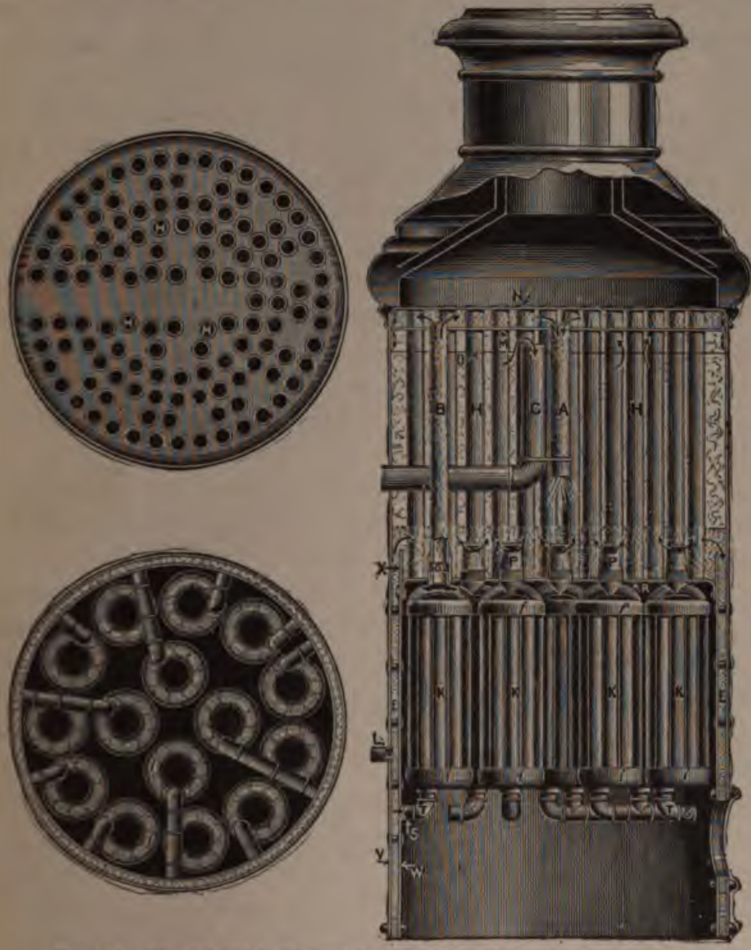


Fig. 197. Vertical and Horizontal Sections of La France Nest-Tube Boiler
Courtesy of American-La France Fire Engine Company, Elmira, New York

pounds pressure. This circuit breaker should be able to interrupt the circuit without injury to itself. Fuses are not allowed, as the necessity of keeping a large supply and the amount of time required for renewing them make them undesirable.

Motor Specifications. The motor may be constructed for whatever kind of circuit it is necessary to use—either alternating or direct. It may operate the pump by being directly attached, or if the motor and pump are to operate at different speeds it may be attached by reduction gearing. The motor must be of such capacity that it can run ten consecutive hours at normal speed—the pump delivering its full capacity at 100 pounds pressure—without the temperature of any part becoming heated more than 104°F. above the temperature of the surrounding atmosphere.

All motors for driving fire pumps must bear a plate giving the name of the manufacturer, the normal voltage, the full load currents, and the normal speed in revolutions per minute.

Automatic Control of Fire Pumps for Electric Power. Fire pumps are required to maintain 100 pounds pressure. With electrically driven pumps, the best assurance that the pressure will remain at the required point is by the use of an automatic controller attached to the motor. Any reduction of the discharged pressure will then automatically start the motor, bringing the pump into operation until the pressure has again reached the point desired. Such automatic controllers must necessarily be substantially built and thoroughly waterproofed. Whenever such a controlling device is used the discharge pipes of the pump should be directly connected by a pipe of the same size to a tank of compressed air kept under the required pressure by an air compressor. The object of this tank is to collect a part of the discharge when the pump is operating and gradually discharge it when the pump is idle—thus steadying the discharge pressure. Without such a tank, the pressure would fluctuate rapidly, and operate the automatic controller too frequently.

For Steam Power. When steam pumps, which are installed for fire purposes only, have once filled the distributing system with water under the required pressure—100 pounds to the square inch at the pump—then, until water is drawn from the system for use on a fire or for test purposes, the work required of the pump is comparatively small, the only duty being to keep up the pressure throughout the system by furnishing an amount of water equal to the leakage. It is often poor economy to run the large pump for this purpose, and, therefore, a small auxiliary pump is installed with devices for automatically controlling both pumps. This little pump should be so attached that it can draw from, and discharge into the main pipes for suction and discharge, and should be of sufficient size to keep up the pressure in the pipes under ordinary conditions. Where, however, excessive leakage or draft upon the system reduces the pressure below the desired point, this lower pressure should allow a valve to open gradually, so as to admit steam to the cylinder of the large pump and cause it to supply the necessary amount of water to bring up the pressure again.

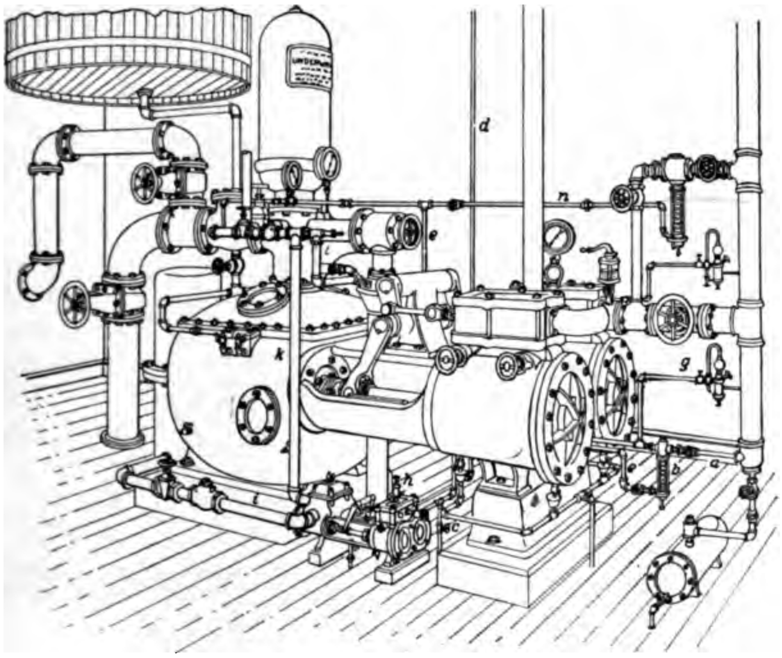


Fig. 198. Duplex Plunger Pump with Smaller Auxiliary Pump Connected in System

Unfortunately, automatically controlled steam pumps are not sufficiently reliable to meet with the general approval of insurance companies. All devices designed for this purpose operate in general, as described, by a spring valve opened and closed by the discharge pressure at the pump. Wherever used for fire purposes the insurance companies demand that these governors be adjustable to obtain any desired pressure between 75 and 125 pounds, using steam from 50 to 200 pounds, and that they be able to govern the pump from slow to full speed without varying in either direction more than five pounds from the water pressure desired. A steam pressure of 200 pounds or a continued water pressure of 240 pounds should not injure the governor or cause it any trouble. The internal mechanisms should be rust proof, as substantial as possible, and all readily accessible for examination or repair; the valve and valve seat should be so arranged that they can be renewed without disconnecting the governor from the piping. Governors for the four sizes of pumps should be 1¼ inches, 1½ inches, 1½ or 2 inches, and 2 inches, respectively.

In Fig. 198 is shown the approved method of attaching an auxiliary pump. Like the main pump the auxiliary should be of the duplex type with all working parts rust proofed. Its relief valve should be capable of passing the full capacity of the pump without allowing the water to rise more than 25 pounds above the point at which the governor is set.

Index of Parts, Fig. 198

a *Steam Supply.*

b *Auxiliary Pump Regulator.* Regulator fittings and connections to be as shown.

c *Steam Supply Drain.* Should be provided with globe valve as shown.

d *Exhaust Pipe.* Should be independent of fire pump exhaust pipe.

e *Water Connection to Regulator.* Brass pipe. Connection must be made outside of check valve in main pump discharge pipe. Globe valve to be placed as shown.

f *Pressure Gauge.*

g *Sight-Feed Lubricator.*

h *Oil Cup.*

i *Suction Pipe.* Connection with main pump suction must be made on a level with auxiliary pump water cylinders. Gate and check valves as shown must be placed in this pipe in all cases.

k *Discharge Pipe.* Connection must be made outside of check valve in main pump discharge pipe. Gate and check valves as shown must be placed in this pipe in all cases.

l *Relief Valve.* Discharges into main waste pipe.

m *Main Pump Regulator.* Regulator to be placed on by-pass with globe valves and fittings as shown. By-pass need not be more than one-third the size of the main steam pipe.

n *Water Connection, Main Pump Regulator.* Brass pipe. Globe valve to be placed as shown.

Pump Drips. To be as shown.

The governor for this small pump should be ¾ inch connected to a ½-inch steam pipe. This small size pipe limits the amount of steam which can be supplied to the little pump, thus preventing its running at tremendous speed when the pressure in the fire system becomes low. The governors on these pumps should be set usually 10 pounds higher than the governor on the main pump, so that this large pump will not start with small changes in pressure.

Pump Houses. *Construction.* So much of the safety and comfort of a community depends upon the water supply that the importance of protecting the pumping station against damage by fire should not be overlooked. The pump house should be of fireproof construction wherever possible, or at least of semi-fireproof construction protected by sprinklers. It should be far enough from the city to escape being destroyed in case of a conflagration, and it should never be a part of or attached to the electric power or gas plant. The pump and the boiler house should preferably be adjacent in order to prevent excessive condensation of steam in long lines of pipe. The boiler and pump house in the case of factories, etc., should be separated from the rest of the plant by a fireproof wall parapet, etc. Both of these rooms should have doors swinging out to facilitate escape in case of accident to the pumps or boiler.

Although it should not be a difficult matter to carry out these requirements in the case of the city supply station, it is often found difficult properly to protect the fire pump room in the case of factories, mills, hotels, department stores, and the like; for of necessity it can not be at any safe distance, and often in fact has to be a part of the building which it is designed to protect. In such a case, the best that can be done is to make the room of the best fireproof construction, with outdoor openings but without any connection to the rest of the building. If electric power is used, the wires for some distance from the pump should be underground.

Air and Light. In all cases there should be ample provision for good ventilation and light. There should be a clear space of three or four feet between the pump and the walls of the house to permit freedom of operating or repairing. Four feet at least must be allowed between the top of the pump and the ceiling so that the priming tank may be at the proper height. Neither pump nor boiler room should contain a closet or any other concealed space.

Heating. Pump houses should be heated so that when the pump is idle the water in it and in the priming tank will not freeze. In cold climates it may be necessary to tap a small steam pipe in the suction pipe to prevent the water here from freezing.

Pump Foundations. These should be of concrete, brick, or stone laid in hydraulic cement. The bolts for bolting the pump should be embedded in the cement as should also be the iron feet of the pump, which should be set level. After the cement has hardened, the nuts should be screwed down firmly on the bolts. Motors also should be securely fastened to firm foundations, although it is not necessary to fasten the steam end so securely. If it is done, the bolts should not be tightened, as some allowance should be made for expansion and contraction with changes of temperature. Wood should never be used for foundations as it is not only too weak to withstand the steam, but ultimately rots.

It is especially important that reciprocating pumps be firmly secured as otherwise a horizontal pump will have a tendency to travel. In all cases, proper foundations and bolting of the pump reduce the amount of vibration attendant to its operation.

PIPE DISTRIBUTING SYSTEMS

Pipe. Experience has shown that for distributing water cast-iron pipe gives the best all around satisfaction. Wrought-iron and riveted steel pipe suffer more from corrosion, and wood stave pipe is not suitable for high pressures; nevertheless, all of these types of pipe are in use at the present time.

Wood Stave Pipe. Wood stave pipe is constructed on the ground where it is to be used, by putting together shaped wooden staves, and holding them by wrought-iron or steel bands. Such pipe is used principally in places to which it would be difficult to transport iron pipe on account of its weight, as is the case in many western localities and places far removed from the railroad.

Cement Pipe. Another kind of pipe which has been used extensively in the east and is still used to some extent, consists of a thin shell of wrought iron coated inside, or both inside and outside with cement. The use of this kind of pipe is rapidly decreasing, however, as it is difficult to keep the cement coating intact; it breaks easily and exposes the wrought iron which quickly rusts out. Frequently long lines of such pipe have been instantly shattered by lightning. At its best, the life of this type of pipe is from fifteen to twenty years; whereas, cast-iron pipe lasts fifty years or more.

Standard Cast-Iron Pipe. The American Waterworks Association issue specifications for standard pipe, and their requirements have been adopted by the National Board of Fire Underwriters, so that pipes for municipal supply, or for fire purposes, should be in general as follows:

CAST-IRON PIPE SPECIFICATIONS

The pipe should be cast and allowed to cool in sand lined moulds. At one end is to be cast a spigot and at the other a bell to make the joints, Fig. 199. The length of pipe exclusive of the bell should be twelve feet.

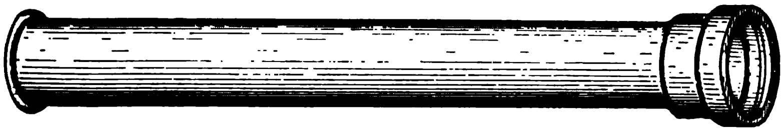


Fig. 199. Standard Cast-Iron Pipe

In laying, the spigot of one pipe is inserted in the bell of the next as shown in Fig. 200, and the joint is made tight by calking and by pouring in lead.

After the pipe is removed from the mould, it should be inspected and rejected if imperfect in shape; or if it shows any imperfections such as blow holes, variations in the thickness, etc. Foundries have their own inspectors for this work, yet the parties ordering the pipe should draw up their own specifications according to standard and have some representative at the foundry who should see that the work is done in accordance with these specifications.

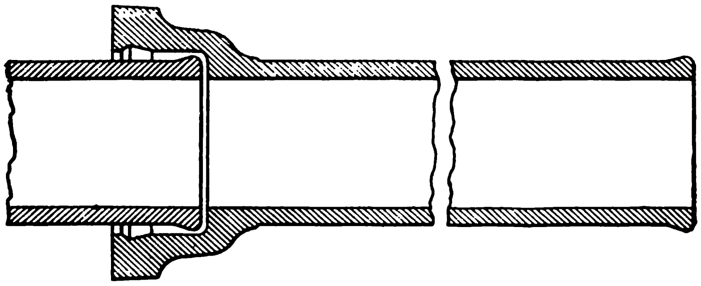


Fig. 200. Section of Cast-Iron Water Pipe Showing Method of Joining Pipes Together

Smooth throatage for the pipe is essential, and to secure this and to proect the surface as far as possible from the bunches of rust or tubercules which orm on water pipe, cast-iron pipe is given a coating of a mixture of tar and nseed oil. The pipe is heated in ovens until it has reached a uniform temperaure of 300°F. It is then dipped, and allowed to remain at least five minutes

TABLE XVII

Standard Thickness and Weights of Cast-Iron Pipe*

Classes A, B, C, D

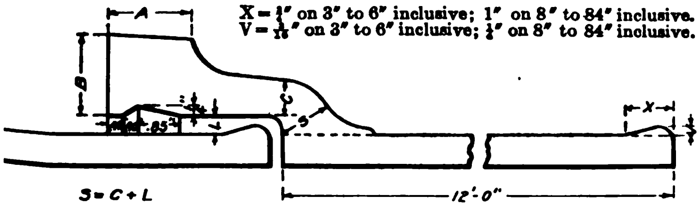
Nominal Inside Diameter Inches	CLASS A 100-Feet Head 43 Pounds Pressure			CLASS B 200-Feet Head 86 Pounds Pressure			CLASS C 300-Feet Head 130 Pounds Pressure			CLASS D 400-Feet Head 173 Pounds Pressure			Nominal Inside Diameter Inches
	Thickness Inches	Weight per Foot	Weight per Length	Thickness Inches	Weight per Foot	Weight per Length	Thickness Inches	Weight per Foot	Weight per Length	Thickness Inches	Weight per Foot	Weight per Length	
4	.42	20.0	240	.45	21.7	260	.48	23.3	280	.52	25.0	300	4
6	.44	30.8	370	.48	33.3	400	.51	35.8	430	.55	38.3	460	6
8	.46	42.9	515	.51	47.5	570	.56	52.1	625	.60	55.8	670	8
10	.50	57.1	685	.57	63.8	765	.62	70.8	850	.68	76.7	920	10
12	.54	72.5	870	.62	82.1	985	.68	91.7	1100	.75	100.0	1200	12
14	.57	89.6	1075	.66	102.5	1230	.74	116.7	1400	.82	129.2	1550	14
16	.60	108.3	1300	.70	125.0	1500	.80	143.8	1725	.89	158.3	1900	16
18	.64	129.2	1550	.75	150.0	1800	.87	175.0	2100	.96	191.7	2300	18
20	.67	150.0	1800	.80	175.0	2100	.92	208.3	2500	1.03	229.2	2750	20
24	.76	204.2	2450	.89	233.3	2800	1.04	279.2	3350	1.16	306.7	3680	24
36	.99	391.7	4700	1.15	454.2	5450	1.36	545.8	6550	1.58	625.0	7500	36
48	1.26	666.7	8000	1.42	750.0	9000	1.71	908.3	10900	1.96	1050.0	12600	48

*American Water Works Association. The above weights are per length to lay 12 feet, including standard sockets; proportionate allowance to be made for any variation.

TABLE XVIII

Standard Dimensions of Pipe*

Classes A, B, C, D



X = ¾" on 3" to 6" inclusive; 1" on 8" to 84" inclusive.
V = $\frac{3}{16}$" on 3" to 6" inclusive; ¼" on 8" to 84" inclusive.

Classes	Actual Outside Diam. Inches	Diam. of Sockets		Depth of Sockets		A	B	C
		Pipe Inches	Special Castings Inches	Pipe Inches	Special Castings Inches			
A	4.80	5.60	5.70	3.50	4.00	1.5	1.30	.65
B—C—D	5.00	5.80	5.70	3.50	4.00	1.5	1.30	.65
A	6.90	7.70	7.80	3.50	4.00	1.5	1.40	.70
B—C—D	7.10	7.90	7.80	3.50	4.00	1.5	1.40	.70
A—B	9.05	9.85	10.00	4.00	4.00	1.5	1.50	.75
C—D	9.30	10.10	10.00	4.00	4.00	1.5	1.50	.75
A—B	11.10	11.90	12.10	4.00	4.00	1.5	1.50	.75
C—D	11.40	12.20	12.10	4.00	4.00	1.5	1.60	.80
A—B	13.20	14.00	14.20	4.00	4.00	1.5	1.60	.80
C—D	13.50	14.30	14.20	4.00	4.00	1.5	1.70	.85
A—B	15.30	16.10	16.10	4.00	4.00	1.5	1.70	.85
C—D	15.65	16.45	16.45	4.00	4.00	1.5	1.80	.90
A—B	17.40	18.40	18.40	4.00	4.00	1.75	1.80	.90
C—D	17.80	18.80	18.80	4.00	4.00	1.75	1.90	1.00
A—B	19.50	20.50	20.50	4.00	4.00	1.75	1.90	.95
C—D	19.92	20.92	20.92	4.00	4.00	1.75	2.10	1.05
A—B	21.60	22.60	22.60	4.00	4.00	1.75	2.00	1.00
C—D	22.06	23.06	23.06	4.00	4.00	1.75	2.30	1.15
A—B	25.80	26.80	26.80	4.00	4.00	2.00	2.10	1.05
C—D	26.32	27.32	27.32	4.00	4.00	2.00	2.50	1.25
A	37.96	38.96	38.96	4.50	4.50	2.00	2.50	1.25
B	38.30	39.30	39.30	4.50	4.50	2.00	2.80	1.40
C	38.70	39.70	39.70	4.50	4.50	2.00	3.10	1.60
D	39.16	40.16	40.16	4.50	4.50	2.00	3.40	1.80
A	50.50	51.50	51.50	5.00	5.00	2.00	3.00	1.50
B	50.80	51.80	51.80	5.00	5.00	2.00	3.30	1.65
C	51.40	52.40	52.40	5.00	5.00	2.00	3.80	1.95
D	51 98	52.98	52.98	5.00	5.00	2.00	4.20	2.20

*American Water Works Association.

TABLE XVII

Standard Thickness and Weights of Cast-Iron Pipe*

Classes A, B, C, D

Nominal Inside Diameter Inches	CLASS A 100-Feet Head 43 Pounds Pressure			CLASS B 200-Feet Head 86 Pounds Pressure			CLASS C 300-Feet Head 130 Pounds Pressure			CLASS D 400-Feet Head 173 Pounds Pressure			Nominal Inside Diameter Inches
	Thickness Inches	Weight per		Thickness Inches	Weight per		Thickness Inches	Weight per		Thickness Inches	Weight per		
		Foot	Length		Foot	Length		Foot	Length		Foot	Length	
4	.42	20.0	240	.45	21.7	260	.48	23.3	280	.52	25.0	300	4
6	.44	30.8	370	.48	33.3	400	.51	35.8	430	.55	38.3	460	6
8	.46	42.9	515	.51	47.5	570	.56	52.1	625	.60	55.8	670	8
10	.50	57.1	685	.57	63.8	765	.62	70.8	850	.68	76.7	920	10
12	.54	72.5	870	.62	82.1	985	.68	91.7	1100	.75	100.0	1200	12
14	.57	89.6	1075	.66	102.5	1230	.74	116.7	1400	.82	129.2	1550	14
16	.60	108.3	1300	.70	125.0	1500	.80	143.8	1725	.89	158.3	1900	16
18	.64	129.2	1550	.75	150.0	1800	.87	175.0	2100	.96	191.7	2300	18
20	.67	150.0	1800	.80	175.0	2100	.92	208.3	2500	1.03	229.2	2750	20
24	.76	204.2	2450	.89	233.3	2800	1.04	279.2	3350	1.16	306.7	3680	24
36	.99	391.7	4700	1.15	454.2	5450	1.36	545.8	6550	1.58	625.0	7500	36
48	1.26	666.7	8000	1.42	750.0	9000	1.71	908.3	10900	1.96	1050.0	12600	48

*American Water Works Association. The above weights are per length to lay 12 feet, including standard sockets; proportionate allowance to be made for any variation.

These principal mains should be at least in duplicate. Leading from the reservoir or pump, they should supply the system at opposite ends, so that in case of breakage of one of them, or a conflagration in one part of the city, the service will not be entirely disabled.

Designing a System. *Water Consumption.* In order to design a distributing system a map of the territory to be supplied should first be prepared, on which is shown the streets to be piped, along with the character of the district, whether business or dwelling, the population of the different districts, and the sections of special hazards—unusually tall buildings or congested conditions—definitely marked. Then should be estimated the probable consumption of these places for manufacturing and domestic use, followed by a computation of the number of fire streams which may be required simultaneously in each section for its proper protection. Authorities vary somewhat in giving estimates of this last consideration; but the fol-

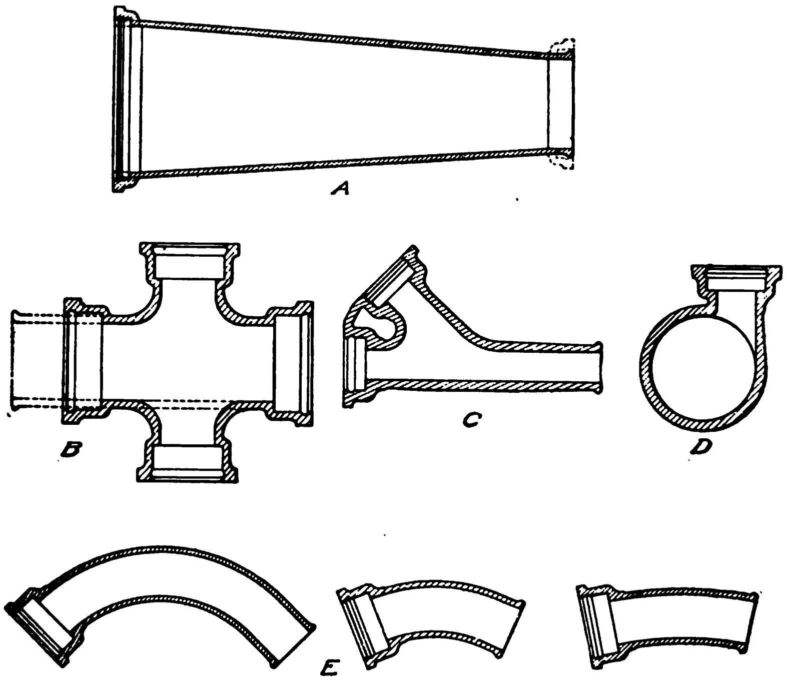


Fig. 201. Typical Sections of Cast-Iron Pipe Bends and Joints

TABLE XIX*

Velocity of Flow and Loss of Head per 1000 Feet in Distributing Pipes When Delivering Given Numbers of 250-Gallon Fire-Streams

Loss of head, in feet, given by light-faced type. Loss of head, in pounds, given by bold-faced type.

No. of 250-gallon Fire-streams	4-Inch		6-Inch		8-Inch		10-Inch		12-Inch		14-Inch		16-Inch		20-Inch		24-Inch		30-Inch		36-Inch	
	Velocity	Loss of Head	Velocity	Loss of Head	Velocity	Loss of Head	Velocity	Loss of Head	Velocity	Loss of Head	Velocity	Loss of Head	Velocity	Loss of Head	Velocity	Loss of Head	Velocity	Loss of Head	Velocity	Loss of Head	Velocity	Loss of Head
1	6.4	50 **21.8**	2.9	7.4 **3.2**																		
2	...	...	5.8	25 **10.9**	3.2	6.4 **2.8**																
3	...	...	8.6	52 **22.6**	4.9	12.8 **5.6**	3.1	4.5 **1.9**														
4	...	...	...	...	6.5	22 **9.6**	4.2	7.4 **3.2**	2.8	3.2 **1.4**												
5	...	...	...	...	7.9	32 **13.9**	5.1	10.9 **4.7**	3.5	4.5 **1.9**	2.6	2.2 **1.0**										
6	...	...	...	...	9.6	43 **18.7**	6.2	15 **6.5**	4.2	6.1 **2.6**	3.0	3.1 **1.3**	2.4	1.6 **.69**								
8	...	...	...	...	...	...	8.2	25 **10.9**	5.7	10.5 **4.6**	4.2	5.0 **2.2**	3.2	2.7 **1.2**								
10	...	...	...	...	...	...	10.2	37 **16.1**	7.1	15.4 **6.7**	5.2	7.3 **3.2**	4.0	3.9 **1.7**	2.6	1.4 **.59**						
12	...	...	...	...	...	...	...	...	8.6	22 **9.6**	6.3	10.2 **4.4**	4.8	5.3 **2.3**	3.1	1.9 **.8**	2.1	0.8 **.35**				
16	...	...	...	...	...	...	...	...	...	...	8.4	17 **7.4**	6.4	9.0 **3.9**	4.1	3.2 **1.4**	2.8	1.3 **.57**				
20	...	...	...	...	...	...	...	...	...	...	...	...	8.0	13 **5.6**	5.1	4.7 **1.6**	3.6	2.0 **.87**	2.3	0.7 **.29**		
25	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6.5	7.0 **3.0**	4.5	3.0 **1.3**	2.9	1.0 **.43**		
30	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7.8	9.5 **4.1**	5.4	4.0 **1.7**	3.4	1.4 **.61**		
40	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7.0	6.5 **2.8**	4.5	2.3 **1.0**	3.1	0.9 **.39**

* "Public Water Supply," Turneaure and Russell.

ving formula, given by Kichling, gives results which are approxitely the average of others in use:

$$y=2.8\sqrt{x}$$

which y is number of hose streams and x is population in thousands.

Hose streams in business and valuable residential districts ould be of standard capacity, 250 to 300 gallons per minute. If onomy is necessary, thinly settled districts or localities where ildings are low, and values small, 175 to 200 gallon streams may

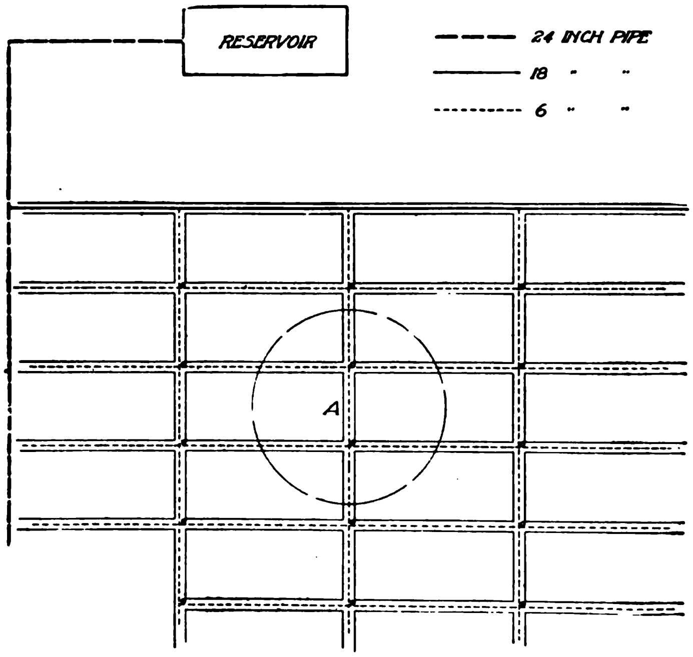


Fig. 202. Gridiron Piping System with Location of Hydrants

provided. With this data, the amount of water required for fire otection can be computed and added to the ordinary consumpn, and thus determined the maximum amount of water to be pplied to each district.

Size of Mains. The arrangement of the pipes can now be roughly termined, and the "head" desired for various points decided upon. ien the data for determining the size of the mains necessary properly supply any point A, Fig. 202, includes (1) static head at A; (2)

head desired at *A*; (3) distance to be traveled to *A*; and (4) amount of water required at *A*.

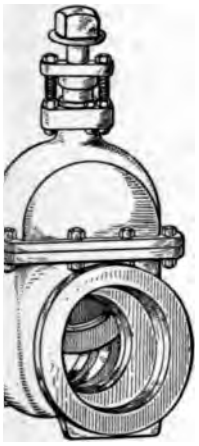
Table XIX gives velocity of flow, and loss of head per 1,000 feet in distributing pipes when delivering a given number of 250-gallon fire streams. If the gridiron system is used in which the pipes are fed from both ends, twice the amount given in the table can be supplied.

When the size of the mains has been approximated and a plan made, the arrangement should be tested from various points. If 12 fire streams are required at *A* with 400 feet or less of hose, we can determine whether the pipes called upon to supply this water are sufficiently large to do so, by indicating about *A* a circle of 300 feet radius, Fig. 202. We find that six lines of 6-inch pipe (fed from one direction by an 18-inch pipe) must supply the water. If the hydrants are properly spaced each pipe must supply two hose streams, or 500 gallons each, beside the domestic consumption. The loss of head in a 6-inch pipe delivering this amount of water would be about eleven pounds to each thousand feet; so if the static head is not great and the distance to be traveled is long, such a pipe would not give good service and an 8-inch pipe would be needed. If the static head is small and steam fire engines are to be used, the question of saving pressure is not of such great importance. Table X shows the relative discharge capacity of pipe. One 8-inch pipe equals 2.05 6-inch pipe, so the introduction of one such pipe into a network of smaller ones greatly increases the discharging capacity of the system; and it is often a better method of furnishing the necessary water than slightly to increase the size of each pipe.

Fire Cisterns. With the "gridiron system," dead ends to a large extent can be avoided. When, however, the irregularity of the growth of the city makes such ends necessary, the best method is to terminate the pipes in a cistern of several thousand gallons capacity, which will collect the water, otherwise lost, when these ends are flushed or blown off, and save it for the use of steam fire engines.

Valves. Beside the determining of the arrangement and size of the pipes, the location of the necessary valves and the hydrants is of the utmost importance.

Gate valves should be installed at regular intervals throughout the system so that in case of accident to the pipes and while repairs being made, the water need be closed off from only a small sec-



203. Typical Gate Valve

A gate valve, Fig. 203, consists of one or two circular disks which can be screwed down into a groove in the pipe, thus entirely closing the passage. On streets these valves are operated from manholes; but in mill yards and in private property, the operating shaft is brought above ground and jacketed into an indicator post from which the valve may be opened or closed.

Indicator posts, Fig. 204, show whether the valves are open or shut by displaying through a little window on its side the word "OPEN" or "SHUT," according to which way the shaft inside is turned. The operating stem must be of bronze finished at the upper end in a solid nut one and one-fourth
s square and one inch high. Some way must be provided to
or strap this valve either open or shut. As for the valves them-
, insurance companies permit either a built-up
olid wedge gate if when open they give an un-
ucted water way the nominal size of the pipes.
s 2½ inches or smaller must have the body and
t made of bronze. For larger sizes they may
de of cast iron, or some other hard close metal.
built-up gate is used, at least one surface must
bronze; and both should be made of this metal
gate fits tightly, thus preventing the rusting to-
r of the parts.

Air and vacuum valves are used at various points
e system to restore it to proper working condi-
For example, when a new system is being filled,
ir in the pipes must have some way of escape as
ater enters. Again, the air which is admitted with
ater has a tendency to accumulate at the highest
s in the pipe lines and in time it seriously inter-
with the flow of the water. To dispose of this air
necessary to have air relief valves at these points.

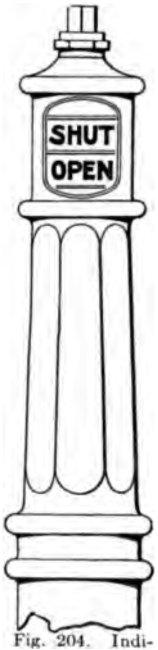


Fig. 204. Indicator Post

When a section of pipe of irregular level is drained, the water water settles in the low parts and vacuums are formed at the summits; and unless air is admitted the pipe is likely to collapse at these points. This can be prevented by installing vacuum valves at such places. Hydrants when properly located may be used both as air and as vacuum valves.

Blow-off valves should be placed at dead-ends and in low parts of the piping systems where sediment is likely to collect, so that the pipes may be flushed out. Mention has already been made of the advantage of a cistern at dead ends. At other points, the water mains should be so connected as to discharge into the sewer when the blow-off valves are opened.

Water hammer, which is caused by the flow of the water in a piping system being suddenly checked by the closing of valves, hydrants, faucets, etc., is sometimes sufficient to break pipes unless air-chambers are installed at intervals or valves used which are arranged to open against the pressure of a spring and to close as the force of the water hammer decreases.

Valves for separating supplies must sometimes be used. For example, if changes of level in the city make two systems, "high and low service," necessary, these two should be connected by valves so that in case of fire in the low part the high pressure system may be made available for use by opening the valve. Again, places having their own pumps for fire service often draw from polluted canals, rivers, etc., the piping system being usually connected by a check valve to the city supply mains from which water can be drawn when the fire pumps are not in operation. When these pumps start and bring great pressure to bear on this check, if it is not perfectly tight, polluted water may leak into the city mains. To prevent this, many plants are installing double check valves, a few feet apart, and are having them regularly inspected to make sure that there is no leakage. Such a course although not prescribed is recommended.

Hydrants. A liberal distribution of hydrants is both a matter of economy and of convenience, for this will avoid the long lengths of hose with their attendant loss of pressure head. Furthermore, hose lasts from five to ten years; whereas, a hydrant lasts fifty years or more, and in the beginning costs less than a length of good hose.

To be easily found, hydrants should be painted red and located us places, preferably on street corners where they will nost noticeable, but will also be useful over the greatest . If the blocks are long, the hydrants on the street ggered; *i. e.*, placed on alternate sides of the street.

drants having two or three or s—the so called "two-way," ' etc.—should be used. On nar- nd in localities where there is no face or flush hydrant, which does ve the level of the street, may under other conditions the post be preferred. The post should y large (never under 5½ inches) necessary amount of water to great loss of pressure head. The ecting the hydrant to the water be at least 6 inches in diameter r three-way, and 8 inches for a drant, which should always be the largest main available. The r riser should be enclosed in a se to protect the hydrants from vent its being forced up by the e ground about it. In this riser also be a drip vent arranged to tically as the hydrant is closed, water remaining in the pipe to o the gutter or into a prepared and gravel, and thus prevent the he hydrant. Great care should see that this vent is not only provided but is kept . Yearly there are disastrous fires before which the fire are nearly helpless, on account of frozen hydrants, due excusable carelessness.

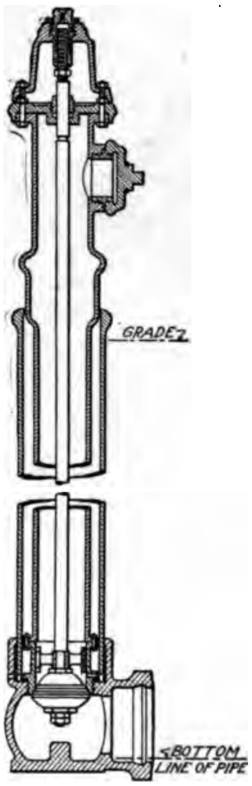


Fig. 205. Section of Michigan Hydrant with Globe Valve
Courtesy Roe Stephens Manufacturing Company, Detroit, Mich.

valves are either gate valves, as already described, or as shown in Figs. 205 and 206, this type of hydrant *compression* hydrants. Some forms of hydrants have ig. 207, so that when repairing the riser, the gate next the main may be closed and the work done without shutting off the water from any section of the city.

Hose Houses. If the management considers its plant of sufficient value to justify the expense of installing and maintaining pump piping and hydrants for private fire protection, it should not overlook the importance of providing hose houses over the separate hydrants, as shown in Fig. 208. Without some such provision for storing the hose and the other necessary equipment at the places where they are to be used it may be found in case of fire that these all important things are at a distance, or perhaps stored in a place to which the fire and smoke make access to them impossible. Moreover, the durability of hose is prolonged by storing it on slatted shelves in well ventilated houses.

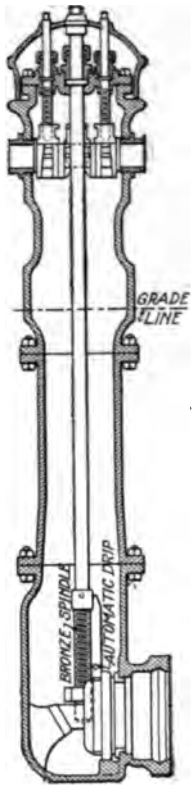


Fig. 206. Section of Chapman Hydrant with Globe Valve

Standard hose houses are usually seven feet high and enclose an area about 6 feet by 6 feet for two- or three-way hydrants, and 8 feet by 8 feet for four-way hydrants. They are supported at each corner by a brick pier 8 inches high and 12 inches square. The roof should be weathertight although there should be an opening under the eaves to permit free circulation of the air. Often no flooring is used and in any case it should only be a slatted one. The doors should be in pairs, hung on heavy tee hinges; should open the whole width of the house; and should swing one foot above the ground.

Proper shelves for the hose are made of 3-inch slats spaced 1½ inches apart. If wider spacing is used, the hose might catch in the opening. A two- or three-way hydrant house should contain one hundred feet of National Standard hose (2⅝ in. diameter, cotton, rubber lined), attached to the hydrants and laid in layers on the lower shelf. A four-way hydrant should have two such lengths of hose attached on opposite sides. On the upper shelf not less than two extra fifty-foot lengths of hose are to be stored. Each house should also contain two axes and have two ladder straps, four spanners, a attached to the hydrant (unless the hydrant is provided hand wheel for opening), a heavy mill lantern, and coiled

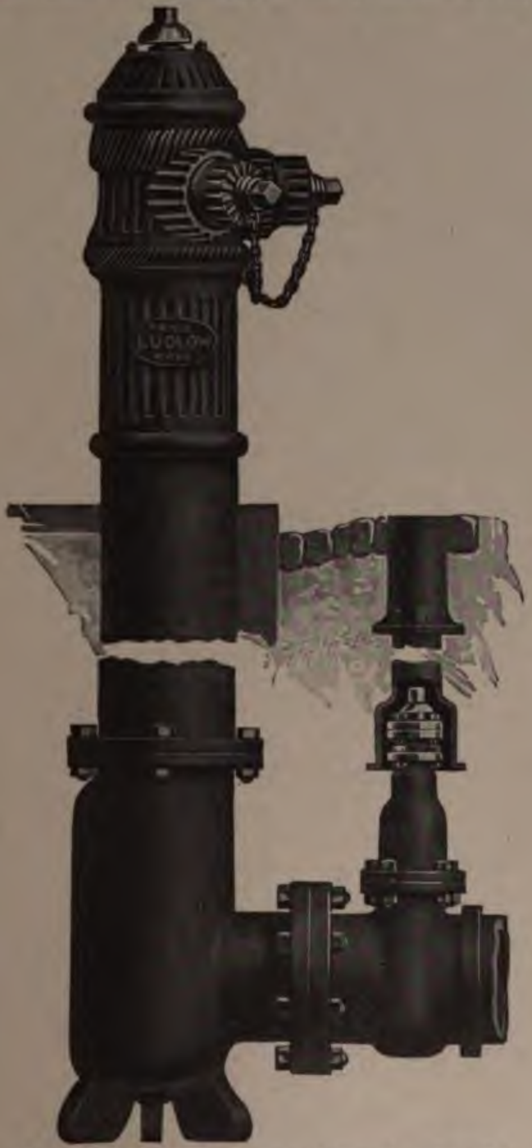


Fig. 207. Slide Gate Hydrant with Secondary Gate Valve
Courtesy Ludlow Valve Manufacturing Company, Troy, New York

of half-inch rope corresponding to the height of the buildings.

Electrolysis. Water pipes are often seriously damaged by stray electric currents which are returning to the power house from some nearby electric railroad. This current enters and flows along the pipe until it reaches some point such as a joint, where the resistance to its flow is large; here it leaves the pipe and goes into the ground, or else overcomes the resistance and continues on the pipes to a point near the power house, where it leaves them to return to its source. No damage is done at the place where the current is picked up, or while it is following the pipes; but at the point where the current leaves and goes into the ground electrolysis is produced, and the pipe decomposed. The amount of the damage done depends upon the amount of the current, and the character of the soil. It is evident that the pipe near the joints and in the vicinity of the power house suffers most from this cause. This damage may be reduced by "bonding" the pipes, that is, by attaching copper wires to them and leading these wires to some point of lower potential such as (a) to the grounded side of the generators at the power house; (b) to "negative feeders". The latter are heavy copper conductors which the railway company frequently run from the grounded side of the generators and attach to various points of their track system; or (c) directly to the tracks. The current leaving the pipes through these

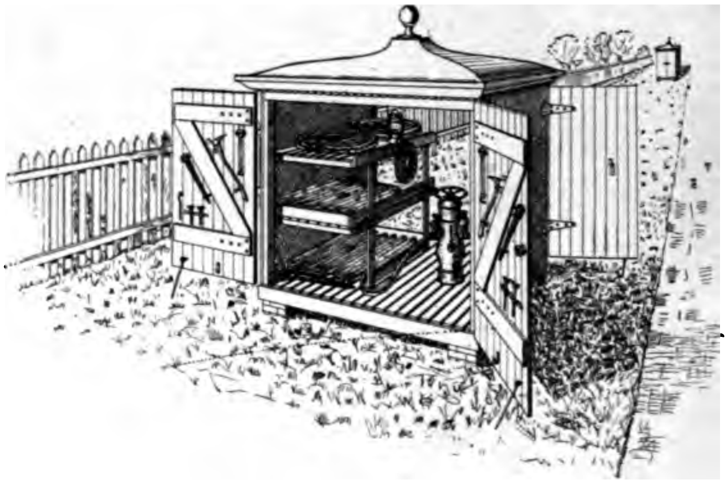


Fig. 208. Approved Form of Hose House Built around Hydrant

loes not enter the ground and thus electrolysis is prevented. ver this is done, care must be taken to have the bonds so that under no conditions of operation of the railroad will a be fed into, instead of being drawn from, the pipes by these ires.

st *Line.* In installing new pipes care must be taken to see ey are below the hydraulic grade line and likewise below the ie. If they are placed in new streets, they must be laid deep to permit the surface of the ground to be removed in subse- rading without bringing them dangerously near the top and the freezing point. In New England, the small mains at ould be from five to seven feet from the surface, and in north- tudes they should be laid even deeper.

CONCLUSIONS

e conditions discussed in the foregoing pages, are those which be maintained in order to secure the best possible fire pro- Insurance companies require that all private water supply conform with respect to pumps, piping, etc., to these speci- s; and that these standards be maintained, if the insured is ve the maximum credit on his premiums for the protection he has installed.

tors Affecting Efficiency of Water Supply. *Low Hydrant e.* In designing a distributing system for a city or town, r, economy is often such a factor that the fire protection he resulting system can afford often falls far short of the ideal. es often find that a gravity head from some natural source hand can be secured, which will give sufficient pressure for y needs; in such a case the maintenance of pumps to furnish ssure would not be economical. Neither is it economy for ties to maintain by pumping a fire pressure over extensive o that the condition most often met is a hydrant pressure s too low for fire service and which must be supplemented engines.

der all conditions, therefore, where water is abundant and hand but where pressure is lacking, the value of the water depends upon, and must be rated according to, the character local fire department and the equipment. Insurance companies rate such departments according to the sufficiency of their equipment of hose, hooks and ladders, and fire engines, and the care taken of them, and according to the organization of the force, as follows:

INSURANCE RATING OF FIRE FIGHTING EQUIPMENT

First Class. Chief, subordinate officers, and full complement of men to each company full paid and permanently housed in company quarters; apparatus to be fully manned and be drawn by horses owned by the department, trained for the service, and used for no other than fire department purposes.

Second Class. Chief, subordinate officers, and the majority of the men of each company full paid and permanently housed in company quarters: the rest of the complement being "call-men" paid for services performed: other conditions as to organization being identical with those nominated for the first class.

Third Class. Engineers, stokers, drivers and tillermen to be full paid and permanently housed in company quarters, the rest of the complement being volunteers. Other conditions as to organizations being identical with second class.

Fourth Class. Engineers and drivers only, full paid and permanently housed at company quarters; rest of the complement being volunteers. Horses belonging to the department, but used for other purposes during the day-time when not on duty in fire service.

Fifth Class. Fully organized and officered volunteer service, under municipal control and with apparatus drawn by hired horses.

Sixth Class. Same as fifth class, but with apparatus drawn by manual power.

Seventh Class. Volunteer service without regular organization, not under municipal control and with manually drawn apparatus.

Private Ownership. Although from any standpoint the private ownership of a community's water supply can not be too severely criticized, such a condition is especially to be condemned by all interested in the fire protection of a locality. Private water companies are run entirely for profit and this financial gain is their first object; whereas, the first considerations of water-supply systems under municipal control are public comfort and public safety.

Communities having to purchase their water from water companies usually pay a specified amount as rental for each hydrant, irrespective of the amount of water used from it; therefore, economy of the water used from these hydrants is desirable to the water company. This economy is easily effected by putting the hydrants on small mains and by keeping the valves closed in the large supply pipes. The number of cities now getting their water from private companies is so alarming that in one instance, at least, the attention of the legislature was called to it and measures asked to prevent it. Too frequently it occurs under such management that property owners and fire departments have to plead in vain for more water and watch property destroyed with their chief source of defense limited by the stubbornness or stinginess of some water official. A community, finding itself in such a position and making any protest, must usually submit or perhaps have its entire water supply withheld, or else pay for its extra privileges whatever the water company may demand.

Meters on Fire Service Pipes. When the water works are owned by the community, it would be natural to suppose that as all such systems are additional protection to the community, the water used in private fire protection systems would be furnished free. Unfortunately, however, experience has shown that large quantities of water are often taken from such systems by ignorant or unscrupulous persons for other than fire purposes; and in order to protect themselves, some cities have been obliged to require meters on all private fire service pipes. From a fire insurance standpoint, this practice is very objectionable; for as yet, no meter satisfactory to both the insurance people and the water works management has been devised.

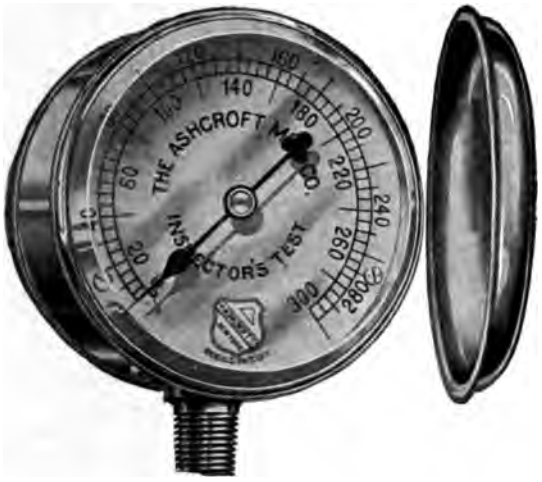


Fig. 209. Inspector's Pressure Gauge
Courtesy Ashcroft Manufacturing Company, New York

Of the meters now in use the *oscillating disk*, the *rotary piston*, and the *reciprocating piston* types measure the water by some positive displacement device (similar to pumps), according to the shape or motion of which they derive their names. These meters are ordinarily quite accurate, though the loss of head from friction in them is great.

The *current meter* contains a sort of water wheel, on a vertical axis, which is revolved by the water flowing by it. The friction loss in this meter is comparatively small, although especially with small flows, it is not so accurate as other types.

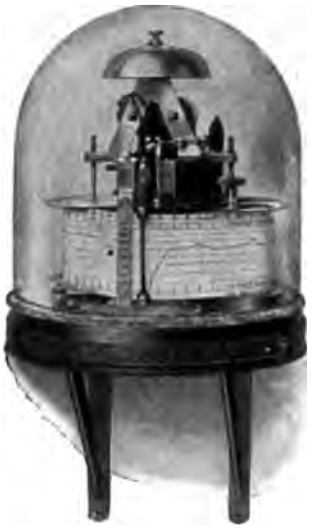


Fig. 210. Edson Pressure Recording and Alarm Gauge
Courtesy Ashcroft Manufacturing Company, New York

The *Venturi meter* consists of a pipe decreasing in size for a distance, then more gradually increasing until it is again the normal diameter. The velocity of the water in passing through this contraction is increased and the pressure decreased. A registering device goes with this which takes the pressure at the entrance to the meter and again at the point of smallest cross section, and from them determines the velocity and the amount of the flow. This registering device is very expensive.

The first three types of meters although approved by the water authorities because of their accuracy, are especially bad from an insurance standpoint; for aside from reducing the pressure they may at any time become clogged with sediment or *debris* and thus allow but very little water to pass. Current and Venturi meters are much less likely to clog up and cause but small friction loss; yet as has been mentioned, they are not sufficiently sensitive to measure small flows, and are, therefore, not so satisfactory to the water management as the former.

Besides the objections noted, the expense of metering apparatus makes it objectionable to property owners. Meters from four to eight inches cost from $175.00 to $650.00; yet in spite of the expense, it is wise to install a meter a size larger than the pipe, or to divide the

ı into several branches with a meter on each, after which the
s should be reunited into one main. By either of these methods,
friction loss may be reduced and the danger of cutting off the
ly by clogging reduced to a minimum.

There are on the market many kinds of meters which are designed
vercome some of the evident faults of the ordinary types; but the
rity of these are arranged to measure only small flows and can
handle the larger amounts such as would be used in case of fire.
difficulty may be overcome in several ways. For example, a
k valve may be installed in the main pipe and a metered by-pass
e around it. Ordinary flows will not open the check but will go
igh by-pass and meter. Large flows, however, will open the
e and the water unmeasured will flow through the main pipe.
n, instead of this check valve a gate valve may be used which is
ated from a post indicator; this should be frequently inspected
e that it is kept closed except in case of fire. Any such schemes
hese which permit the water for fire purposes to flow unob-
cted are preferable to placing a meter on the main pipe.

When the object is simply to prevent water from being used for
r than fire purposes, this may usually be accomplished by install-
an alarm valve arranged to ring an alarm at the pumping station,
engine house, or wherever else desired, whenever water flows into
ire pipes. These alarms have none of the objectionable features
eters and are therefore largely used. See "Alarm Valves," Fire
rance Inspection III.

Inspection of Water Supply. In inspecting a water supply
em, the features which have been explained in the foregoing
ters should be investigated and reported upon. For testing
sure, the inspector is usually given a pressure gauge, Fig. 209. The
p's capacity is shown on the plate and many pumps are fitted
a recording pressure gauge, Fig. 210, which is arranged to hold a
of scaled paper, upon which a point controlled by the pressure
s a continuous record of this pressure. These records should
be examined by the inspector. From such sources as these, and
observations and questionings, the desired information may be
cted, and deductions made. However, to obtain the most
rate knowledge of what can be expected of a water supply sys-
the method to be followed *whenever possible* is to give the system

an actual test through hose lines exactly as might be required by a possible fire. Only by such a test can the combined influences of the corrosion of the pipes, the friction due to velocity of flow and bends in the pipe, and many other variable factors, be determined.

FIRE INSURANCE INSPECTION

PART V

PUBLIC FIRE PROTECTION

Every community, according to its size, has a greater or less sponsibility toward its citizens in the matter of fire prevention d fire protection. To prevent fires, cities and large towns make d enforce laws and ordinances regarding building construction; e sale and storage of inflammable liquids, explosives, etc.; the care d occupancy of buildings; the installation of power and heating paratus; the collection and disposal of rubbish; and the doing of merous other things where any carelessness in individual manage- ent might jeopardize the public safety. To protect against fire ste, fire departments and their auxiliaries are organized, equipped, d maintained. According to the excellency of its laws, the rigidity th which they are enforced, and the efficiency of its fire depart- ent and the fire department auxiliaries, the fire record of a com- unity is creditable or otherwise.

FIRE PREVENTION AUXILIARIES

Insurance Company Provisions. Politics, individual interests, d other considerations so often enter into law-making that insur- ce companies have to supplement city and town ordinances with quirements of their own, to which any risk must comply before it n obtain insurance from any particular company in question. surance companies through the medium of the National Board Fire Underwriters, The Associated Factory Mutuals, The National re Protective Association, and such organizations, issue specifica- ns for standards of materials, construction, and apparatus, and ke suitable rate reductions when a risk substitutes any standard ture for one not approved. They also pass ordinances for the

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from the electrical department should make frequent inspections to see that their requirements are met and to order any changes they may find necessary.

Before any company is allowed to turn the current on to any new wiring, they are required to see that the electrical department has issued a properly filled-out certificate to the effect that the electrical installations are safely and satisfactorily made.

Bureau of Combustibles. The Bureau of Combustibles is obviously established to dictate concerning the safe storage, transportation, and sale of inflammable liquids and explosives. Where such a bureau does not exist, this work may be done by men appointed from the fire department by the fire marshal or by the fire wardens.

Fire Marshal and Fire Wardens. The duty of the Fire Marshal or Fire Wardens is to investigate fires in order to determine their cause and to see that arson is prosecuted. In some places they also see to the buying, testing, etc., of the fire-fighting equipment. In large places these men are usually chosen from the fire department, and they may also be given the care of combustibles. In small places, however, attention is seldom paid to the regular occupation of the marshals or wardens. Here such officers are elected by ballot, and their duties include not only the investigating of fires, but the enforcing of certain local laws, such as prohibiting fires outdoors during certain seasons, etc. In the deficiency of a fire department, the fire warden should call out and direct the citizens in fighting any fire that may occur within his district.

Police Department. The Police Department may be considered a fire department auxiliary since it greatly aids in detecting fires and sending in alarms. This department is usually required to send a squad of men to fires—usually not until the second alarm—to establish fire lines and to keep lookers-on and the general traffic from interfering with the free work of the firemen.

Insurance Patrol. The Insurance Patrol or Salvage Corps is organized and maintained by insurance companies for the purpose of saving property at a fire. These men respond to second alarm fires and bring with them tarpaulins for covering goods to protect them from getting wet or injured by the ashes or the falling of burned or wet material. These men may remove stock whenever necessary and in general see that no avoidable waste or damage occurs.

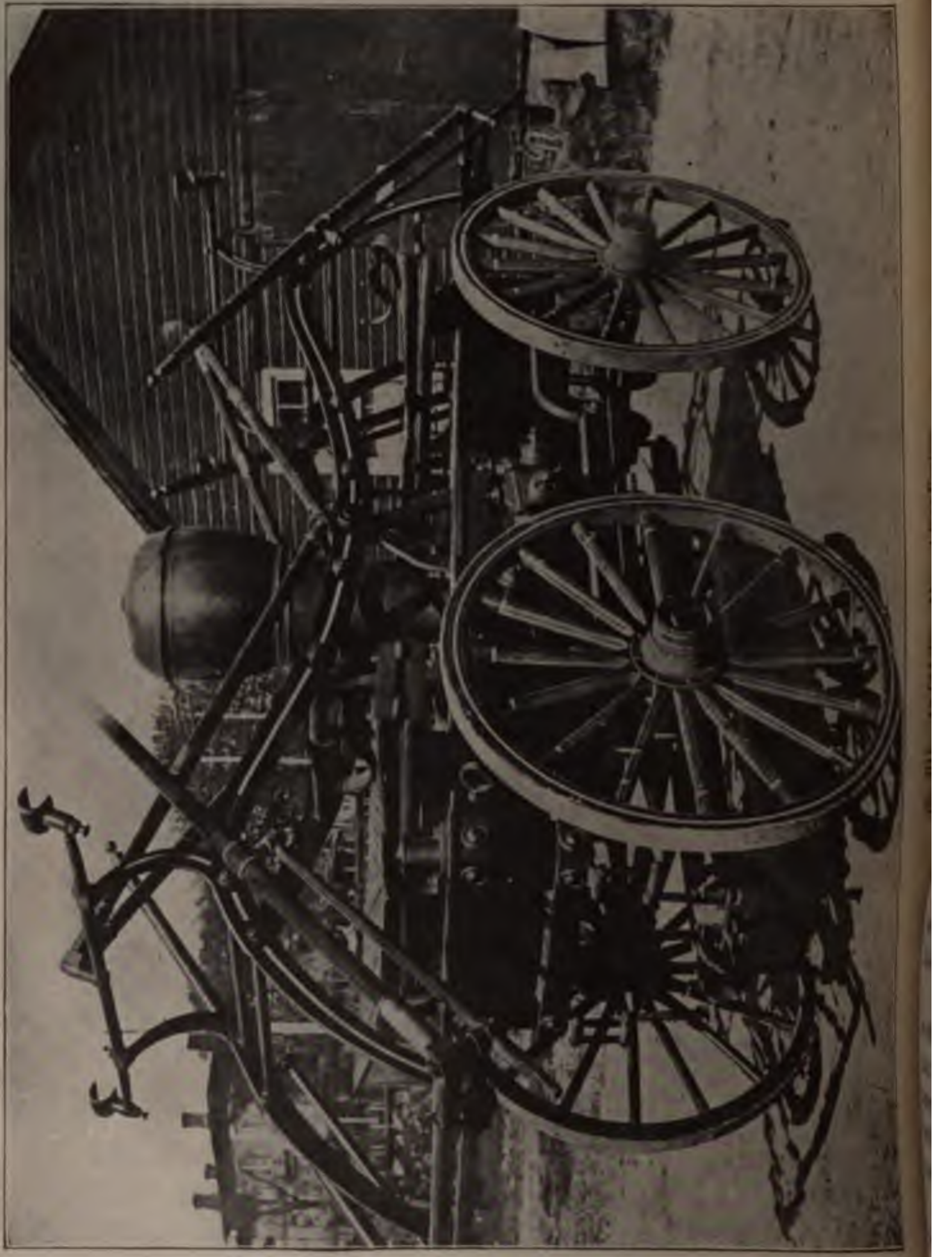
Miscellaneous Auxiliaries. In all cities and in most large towns exists one or more bodies of influential business men organized he purpose of protecting the business interests and of promot- the general welfare of the city. The Chamber of Commerce, Committee on Public Safety, The Merchants' Fire Protective ciation, and such organizations do great good in making recom- dations and urging changes. Most city fire reports show that bodies of men have effected the widening of narrow streets, the ovement of the paving, the removal of overhead wiring, and in erous other ways have facilitated fire fighting and reduced the fire hazard.

The Chambers of Commerce in Rochester, N. Y., and in Boston carried on active campaigns for the prevention of fires in their s. They have issued literature intended to instruct their citizens erning the subject and to bring them to a realization of their idual responsibility. They have urged and effected such ovements within the lines of fire prevention and fire protection other cities would do well to follow their valuable examples.

FIRE DEPARTMENTS

History. Soon after the London fire in 1666, we find the first insurance companies organized and almost simultaneously with came the first organized fire-fighting brigade. When a company ed a building, it affixed to it a plate designating the fact. Each ance company maintained a fire brigade and owned its own ratus. A watch tower system of alarms was employed and, any alarm was heard from these towers, each company sent ts fire department to find the fire. If the building was insured ie of the responding companies, their brigade stayed and fought ames while the other departments, after determining that none e property insured by their company was exposed to danger, ned to their quarters without lending assistance.

inally, however, these separate companies were combined into ieral and more effective fire department. From this small ning—with the gradually increasing need of a body of skilled ghters, and with the advance of science which has caused the old al engine, Fig. 211, with its attached tank of water to be replaced e modern steam or gas driven pumping engine, Figs. 226 and



227, drawing from the municipal supply mains—our present fire departments have developed.

The equipment and personnel of the numerous fire departments of our country today are as greatly diverse as the population and means of our different cities and towns, and in general they correspond to these last two factors. The fire-fighting facilities of a community are likely to be a much more accurate index of its liberality in appropriations than of its needs in this direction.

Support. Statistics show that towns of from 5,000 to 10,000 population appropriate from 20 to 70 cents, or an average of 42 cents per capita annually for fire-fighting purposes; while our largest and most progressive cities appropriate more than $200 per capita. In many smaller towns these scant appropriations are annually expended in wardens' fees, fighting forest fires, etc., leaving nothing with which to buy apparatus or to maintain any kind of a fire department. When such towns possess any equipment, it is most often the gift of the village improvement society or some other similar organization.

DEPARTMENT PERSONNEL

Classes of Firemen. The fire fighters of this country may be generally classified as volunteers, call men, and full paid men.

Volunteers. The majority of firemen in the United States are volunteers. Although there is record of much excellent service on their part, and many towns are unable to support any other kind of a company, yet so many are the drawbacks and uncertainties connected with volunteer work that a paid department, however slight the requital, will usually be found to give much more efficient service.

Volunteer companies are often too large to be easily disciplined or directed at a fire. The officers are usually elected by ballot and may or may not be competent to fill their positions. From the nature of the service, dependence can not be made upon the regularity of the attendance of the members, or of the best among them responding to a call.

Many incentives to prompt work and good attendance have been tried—as when there is more than one company in a town, a certain sum of money is given to the company which gets the first stream of water over a fire. Although valuable to a certain extent, any method which stimulates rivalry between the companies is dangerous, for then company interest and not the town's welfare is made the important object. This develops the tendency for one company to oppose any needed improvement in apparatus or personnel in another district—if it is to be of benefit to another company.

In the case of forest fires or other large fires near small villages, even though there be some sort of a fire department, volunteers are usually the chief defense. Fire wardens or the officers of the fire department may direct the work. Such volunteers are usually compensated according to the number of hours which they have spent in work.

Call Men. These are men who, although they have some other regular business, are duly appointed members of a fire company and are expected to respond to alarms of fire within their districts. Such men receive pay for their services and in many towns they are fined if they fail to respond to an alarm within a prescribed time limit and have not a valid or sufficient excuse. Call men should be chosen from those whose business is near the company of which they are members. The service from this class of firemen is usually good and many important cities have districts protected by companies made up wholly or in part of call men.

Full Paid Men. This class includes a wide range from the one full paid official, who is found in many country towns and who manages the apparatus and keeps a general lookout on the fire situation, to the trained members and skilled officials of our best city fire departments.

Selection of Firemen. In a city small enough for the chief of the fire department to know all his men, he may select his subordinates himself from the applicants, and be held directly responsible for their work. In some places appointments are made from among those who have served as call men or as substitutes, and in those capacities have had their ability tried. Where this course is impracticable or for political or other reasons inexpedient, selection by civil service tests has given the best results. This method has met with some opposition because the mental requirements often bar men of excellent physique and of seemingly admirable equipment for fire fighting. At present this can be no serious objection as there are so many applicants for fire department positions that there is no

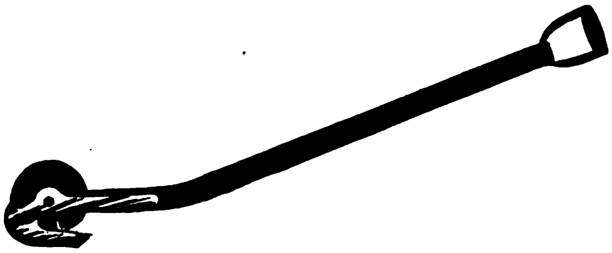


Fig. 212. Hale Tin Roof Cutter
Courtesy American-La France Fire Engine Company, Elmira, New York

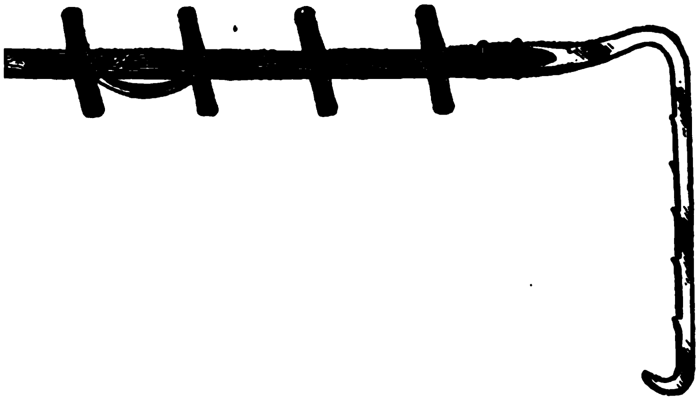


Fig. 213. Pompier Ladders
Courtesy American-La France Fire Engine Company, Elmira, New York

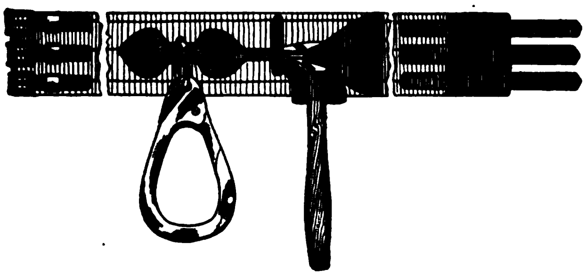


Fig. 214. Pompier Life Belts
Courtesy American La-France Fire Engine Company, Elmira, New York

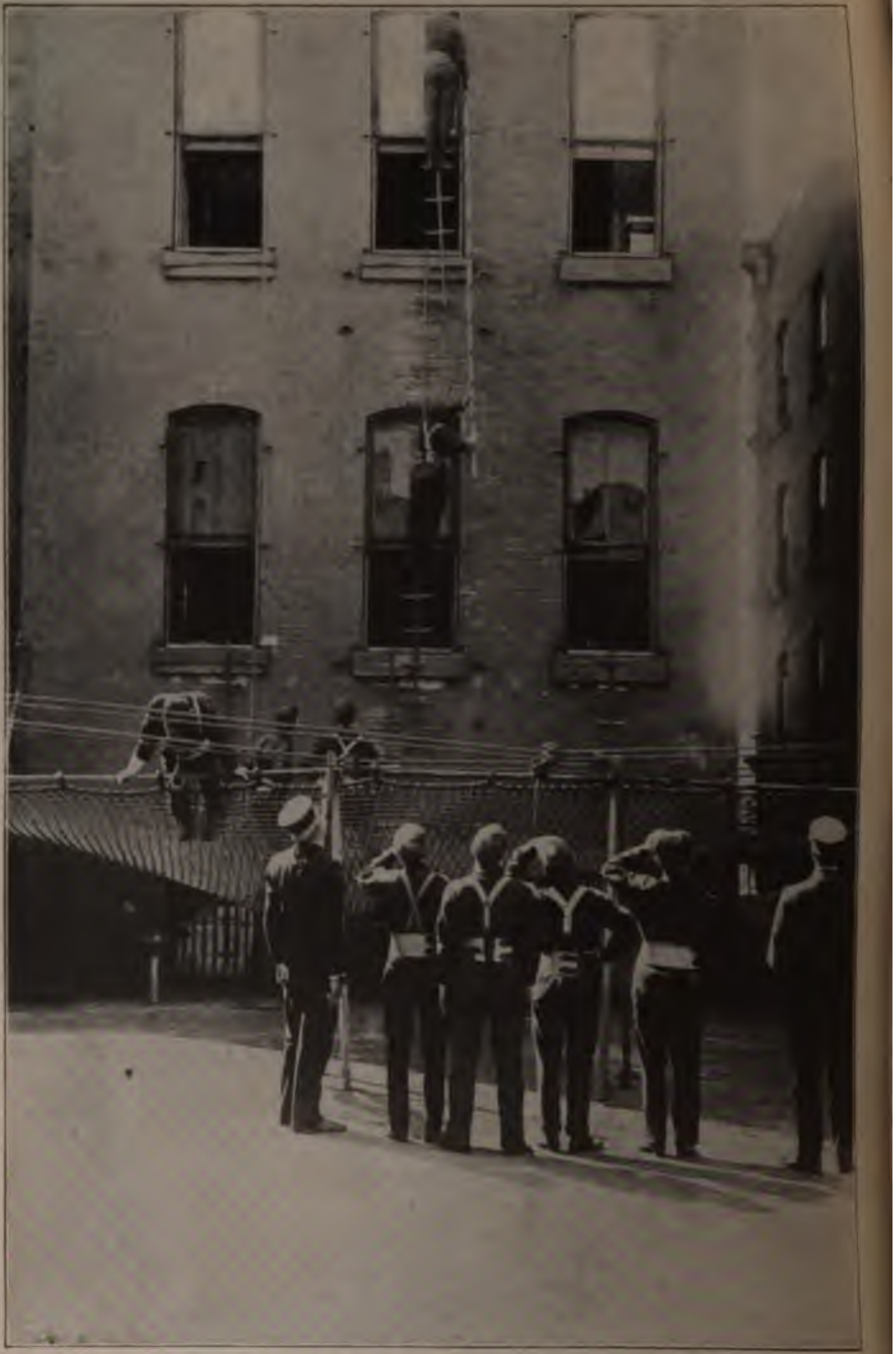


Fig. 215. Practice in Use of Scaling Ladders and Life Net at New York Firemen's College

difficulty in finding men suitably equipped both mentally and physically. For the very reason that part of the cry against this method is probably inspired by politicians who are no longer able to place men upon the force or to remove them, the civil service method will probably bring about greater efficiency in the department.

Training the Men. In small towns or cities where the buildings are not high, firemen will need only such training as can be obtained from the drills and under the direction of the fire department officials, and since these men often serve first as call men or as substitutes, they enter the department with all the preliminary training that is necessary. For work in large cities, however, considerable skill is required. To train firemen and to make sure of their ability before they are added to the active force, cities provide various kinds of schools, ranging from the usual probationary school to the firemen's college, recently established in New York City for the preparation of the firemen who enter that city's service.

Probation School Work. The thirty or more days' training of the usual probationers' school is exclusively practical and is carried on under the instruction of the officers of the department. The new men are trained in the use of the apparatus necessary for entering any part of a building, such as crowbars, battering-rams, door openers, tin roof cutters, Fig. 212, lock openers, etc.; and in the raising and management of all kinds of ladders, with especial drills to obtain skill in using the hardwood hooked-top scaling ladders, Fig. 213. By hanging the hook of these ladders over a window sill or the top of a cornice and making use of life belts, Fig. 214, which allow the free use of both hands, the men are able to reach any floor or the roof of a building where it is desired to carry up rope, hose, or other life- or property-saving apparatus, as shown in Fig. 215. They are taught to hold, to lift, to lower, or otherwise to give such help to their companions as might be required in difficult rescue work, Fig. 216. They are required to practice in making the different kinds of knots needed in their work, and in using the life rope gun by which a line is shot to the roof or to a window so that a life rope may be drawn up and secured, Fig. 217. They are drilled both in holding and in jumping into the life net, Fig. 218, for it may happen that all ways of escape may be cut off for a fireman left on a roof or in a window, and his only chance may be a leap into the fire net. They practice in making connections between hydrant and engine, attaching hose either to hydrant or to engines, making siamese and other connections such as to standpipes, automatic sprinkler systems, and in handling inside hose streams. Beyond this they are instructed how to send alarms, police and ambulance calls, and in some places they are even given a slight but practical course in first aid to the injured. If the city has a high pressure system, the use of the high pressure handling devices is included in the course.

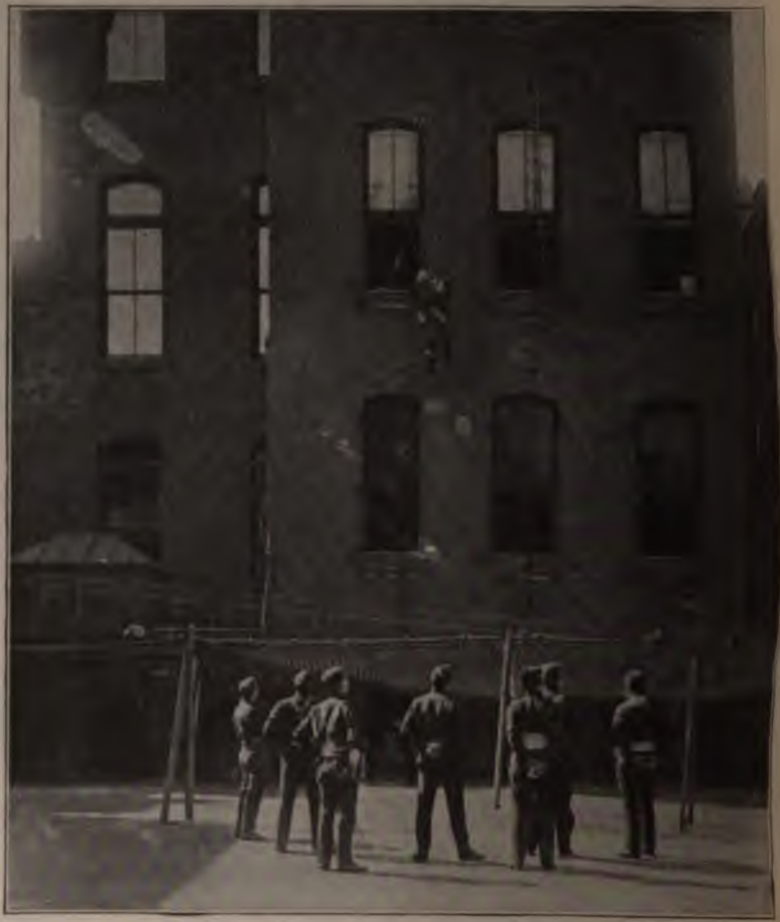


Fig. 216. Practice in Rescue Work at New York Firemen's College

New York College. The New York College, which will probably be a model for similar schools in other cities, besides amplifying this general course, includes departments for the special training of officers, engineers, and chauffeurs. This school is opened to the firemen upon approved application, and henceforth only graduates of it will be selected to fill the positions for which the special training is given.

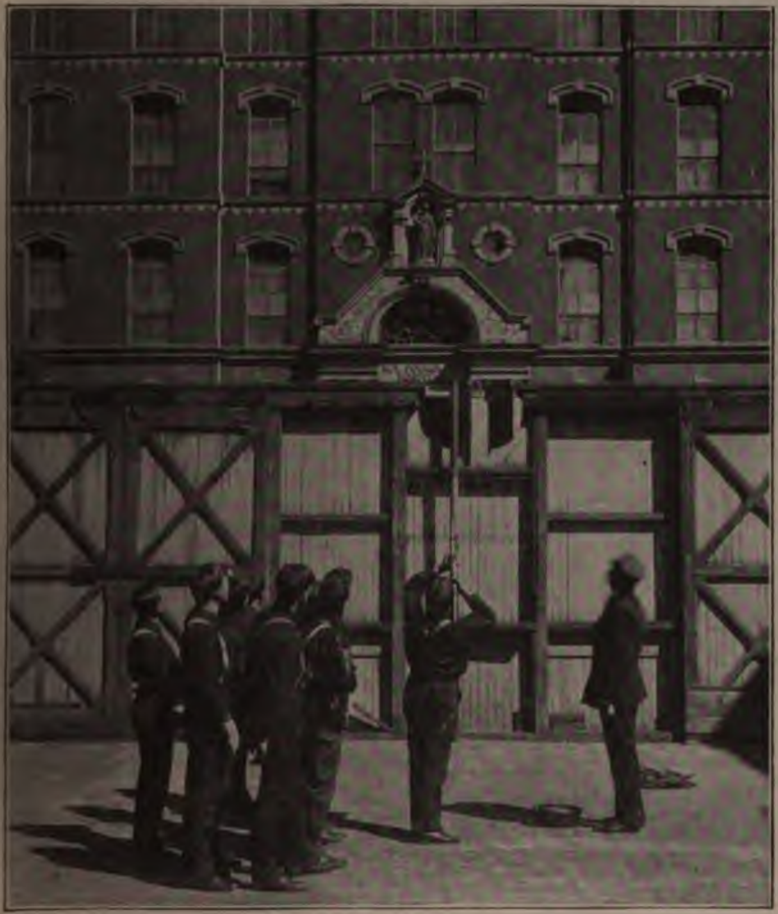


Fig. 217. Shooting Life Line Gun in Rescue Work

The engineers and chauffeurs are trained in the machine shops and repair shops of the department and become thoroughly familiar with the parts and the operations of both steam and gasoline engines and motor apparatus.

In the officers' schools, the instruction is given by those officers of the department who have had the widest and most valuable experience and have developed practical methods.

In the company schools, whole companies are sent to receive various kinds of instruction, such as in the use of special apparatus,

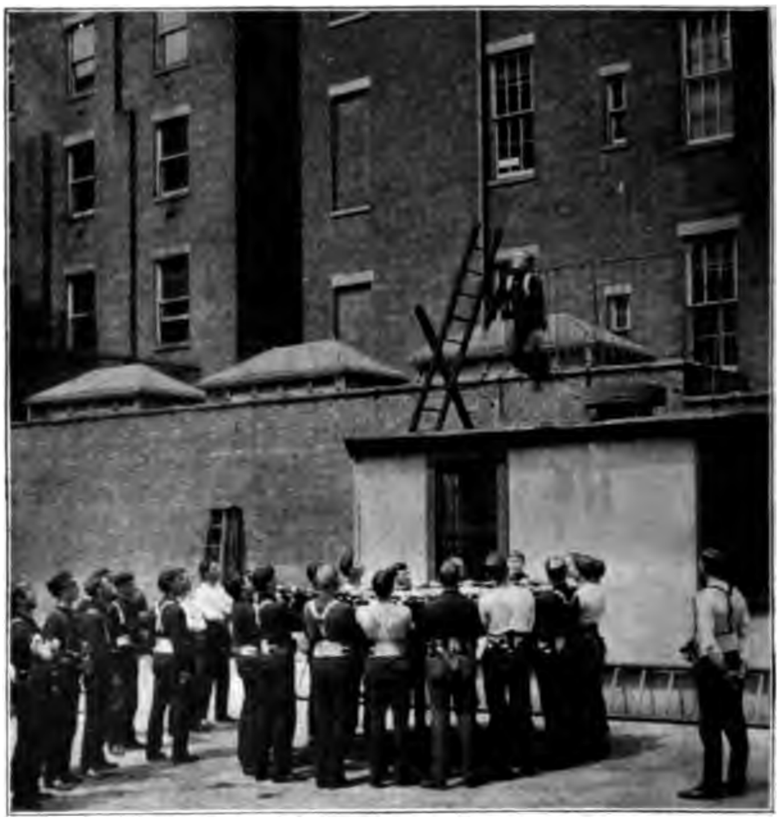


Fig. 218. A Leap into the Life Net

or of the high pressure system. In case of conflagrations, any city company may be called to aid in the threatened district.

Treatment of Dangerous Fires. As some fires more than others present difficulties and dangers to the fireman which he should understand before being assigned to active service, so most courses include lessons on these points. The fireman must know primarily that at all times and without hesitation he must obey the officers in charge, who from the best point of vantage obtainable can see dangers and conditions indiscernible to the workers at close range; that he must work coolly and sensibly with his mates and not wander off working at his own discretion. He should know that water should not be used on fires when grease, oil, tar, paint, and such materials are likely to cause the fire to spread by being floated about; he should know where such inflammables are likely to be encountered, as in automobile garages, paint stores, drug stores, cleaning houses, etc.; that water should not be used on electric fires, as the stream from the hose may become charged and do serious injury to those operating it; that water should not be used on burning nitro-glycerine, guncotton, forcite, dynamite, or such explosive compounds, since it will invariably cause an explosion. He must remember that calcium carbide when wet produces an explosive gas and that no exposed flame should be brought near it; that ammonia used in ice manufacture and in refrigerating, though it will not burn, will explode when heated in tanks; and that the fumes of ammonia, acids, sulphur, and of many other chemicals being injurious to the lungs, any building where such fumes are likely to be present, either should be thoroughly ventilated, before entered, or the fumes be scattered by introducing a spray of water. In ship fires, drug store fires, and warehouse fires, many dangerous and explosive gases are likely to be present. Where lime is stored it is best not to use water as this causes the lime to heat, slack, burst the barrels, and thus add to the fire. Wherever the use of water is dangerous, wet sand, ashes or dirt, wet cloths, chemical powder or pyrene should be substituted.

Company Organization. The kind of fire department found in a town or city depends to a very large extent upon the financial support of the community. The fire service in small villages is usually too slight to demand the maintenance of any form of fire department. As the village grows, the first steps will probably be to buy fire-fighting equipment and to organize a volunteer company. When the public safety demands or the finances permit, the volunteer service is often replaced by a force partly composed of paid call men and partly of volunteers. Where such a combination has been preceded by an entirely volunteer service, trouble often ensues from the volunteers leaving all the work to the paid men. Occasionally towns of this size have a full paid chief of some training or experience who devotes his entire

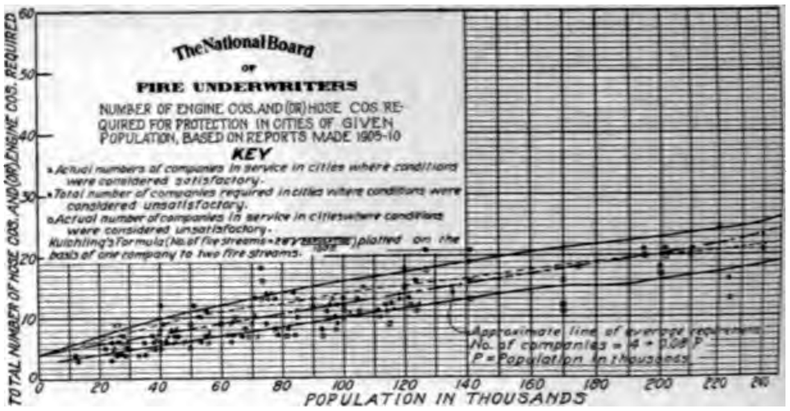


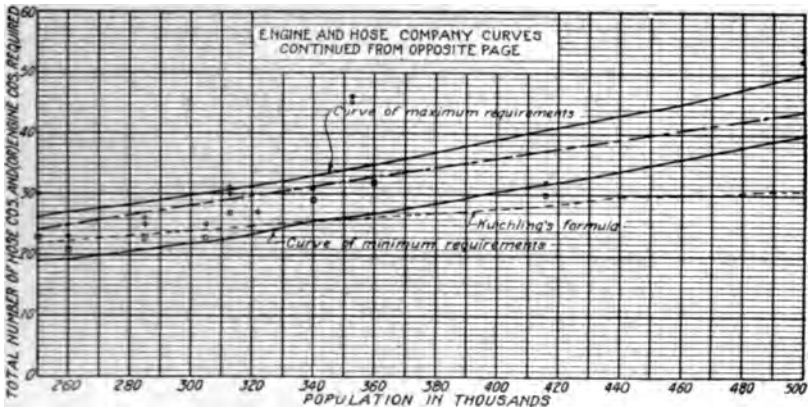
Fig. 219. Curves Showing Number of Engine and

time to fire protection work, while the rest of the force is entirely volunteer. The next step is usually to eliminate all volunteer workers and to have in their stead part paid call men or a small force of full paid men supplemented by call men. This last arrangement is used in many places, the greatest variance being in the way the full paid men are divided, *i.e.*, whether they are scattered and constitute the officers of several companies of call men, or whether they are combined into one or more complete companies. The size of the city and other local conditions must determine the best method of distributing these full paid men. In densely populated or valuable districts of our cities, full paid forces exclusively should be found.

Size of Companies. For all cities large enough to support a fully paid fire department, the National Board of Fire Underwriters has made a standard recommendation that at least seven men should at all times be present in each engine or ladder company situated near the mercantile or manufacturing districts. In other engine or ladder companies, not fewer than five men should be constantly on duty.

A company of seven men allows for one officer; two drivers, one for the engine and one for the hose wagon; engineer with an assistant; and two men to handle the hose. In a five-man company, the drivers must help with the hose. For large fires, for work in high buildings, and for handling high pressure streams, more than two or three men are required to handle the hose, and thus help from other companies or from volunteers must be called.

In order to keep at all times from five to seven men on duty in



Hose Companies Required in Cities of Given Population

an engine house, it is necessary for the companies to have a membership of from ten to fourteen men. The firemen in most cities are usually allowed three hours daily for meals; from three to six days' leave each month; and from two weeks' to a month's vacation. This means approximately that at all times half the force would be away—some to meals, some on leave, and some on vacation.

Fire Department Divisions. The company officers are generally a captain and a lieutenant. The companies are arranged by districts into groups called "battalions" which are under the supervision of battalion chiefs, and which in best practice are made up from five to eight companies. These battalions are further arranged in groups and each group put under the management of a deputy chief who in turn reports to the chief of the fire department. This chief in some cities reports directly to the mayor, aldermen, or city council, and since he often receives his appointment from one of these parties, he is not put in for a definite term, but is dependent upon these men for the tenure of his position. Such an order of things too frequently tends to modify both work and reports and is not likely to bring about the best department management; yet the fact that this system has been successful in several cases, shows that the ability and integrity of the chief determines the case and not the arrangement of the system. Between the mayor and the fire chief there are most frequently other officials—such as a fire commissioner, or a body of three or more fire commissioners.

There is no uniformity in the grouping of the different divisions

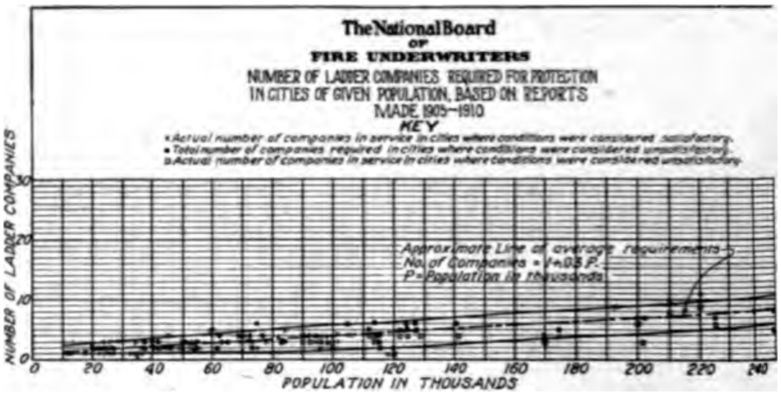
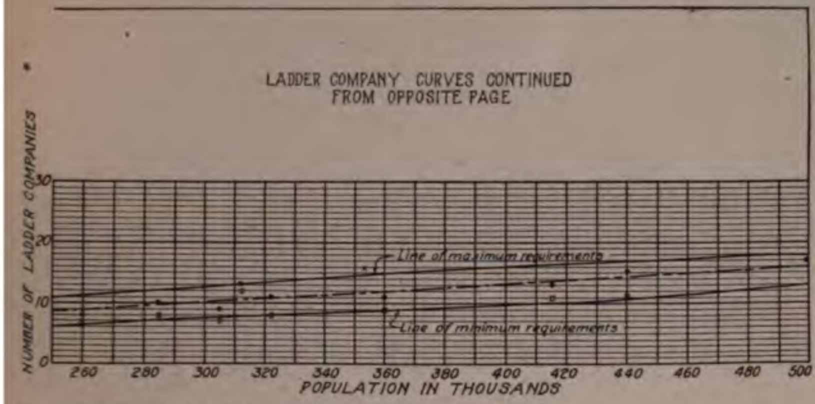


Fig. 220. Curves Showing Number of Ladder

of a city fire department, nor in the way in which it is governed. One city may have a great many districts with but five battalions in each, while another may divide a large number of battalions into a few districts. A method successful in one place may for political reasons or because of the personality of those in power be a failure in another.

The National Board of Fire Underwriters is now doing the work originally assigned to a "Committee of Twenty." Its duty is to investigate and report upon the conditions found in the fire departments of the cities in the United States, and to make recommendations concerning any changes of which it may find need. From its study of methods, conditions, and results in so many places, this department has been exceptionally well fitted to treat separate cases with an understanding and equipment which has not before been applied to this work and it has therefore been able to effect many valuable improvements. Its recommendations cover all the ground of interest to fire departments, from their management to the details of their equipment. The curves shown in Figs. 219 and 220 are derived from data they have collected.

Fire Department Quarters. The first apparatus a town buys is usually stored in some centrally located barn, or a room provided for the purpose in one of the public buildings. When the question of obtaining new and separate headquarters for the department arises, there are certain important considerations which should not be neglected. The lot devoted to it should be within or near the district where the greatest values and the most use for the service are



Companies Required in Cities of Given Population

likely to be found; it should be sufficiently large to permit of ultimately enlarging the fire department building to accommodate the equipment which will probably be needed many years hence.

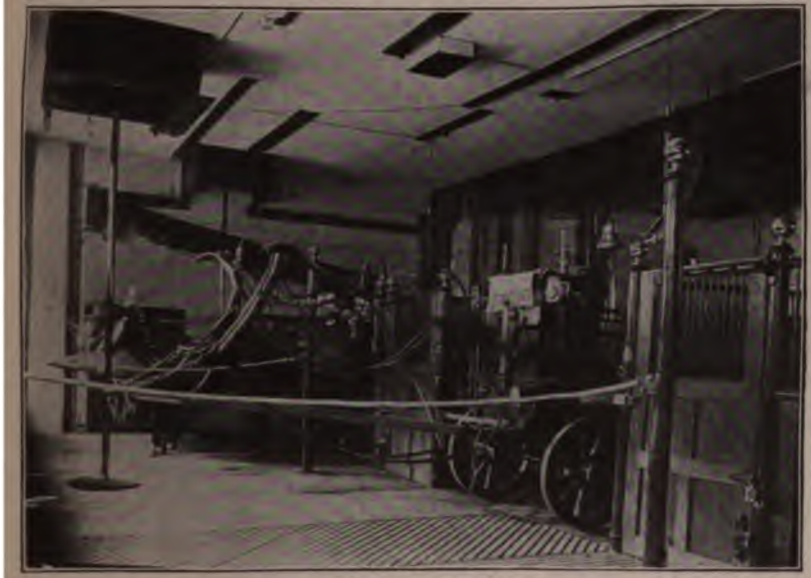


Fig. 221. Typical Interior of Engine House, New London Fire Station

Since fire-fighting apparatus is very heavy and unwieldy, the engine house should be so located that a steep grade or a sharp turn at the outset may be avoided. The building should be as nearly fireproof as possible and not situated so as to be exposed to any especial hazard.

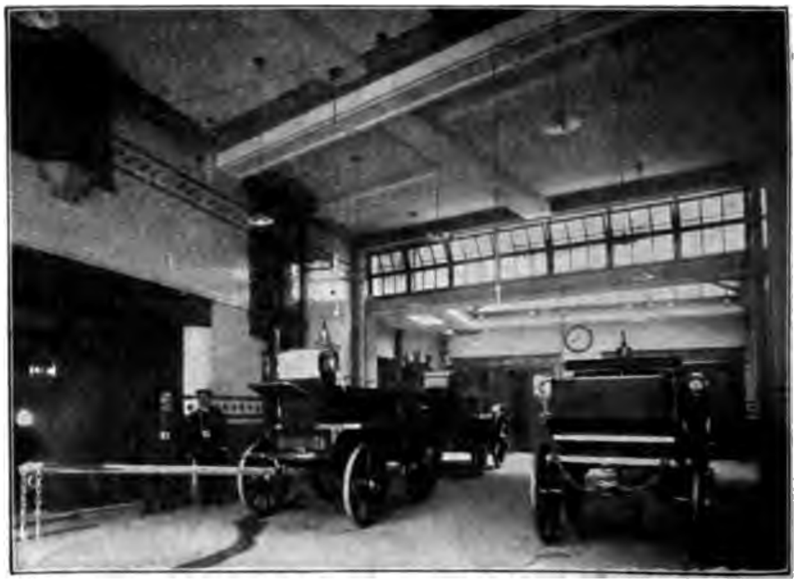


Fig. 222. Trap Room of London Salvage Corps

Fig. 223. Action in Firemen's Sleeping Apartments Immediately After Alarm

A city fire engine house should provide on the first floor the mpany offices and rooms for the engine and hose wagon, or for e ladder truck; and in rooms adjacent, quarters for the horses (See igs. 221 and 222). Besides the ordinary heating apparatus, etc., e basement should contain a boiler heater to be attached in order at it may keep up steam in the engine boiler while it is idle. Above e first floor the reshould be quarters for the men, with brass or other nooth poles installed down which the firemen may slide, and thus ve time in answering alarms, Figs. 223 and 224. These firemen's uarters may be as sumptuous as the city or the men themselves see

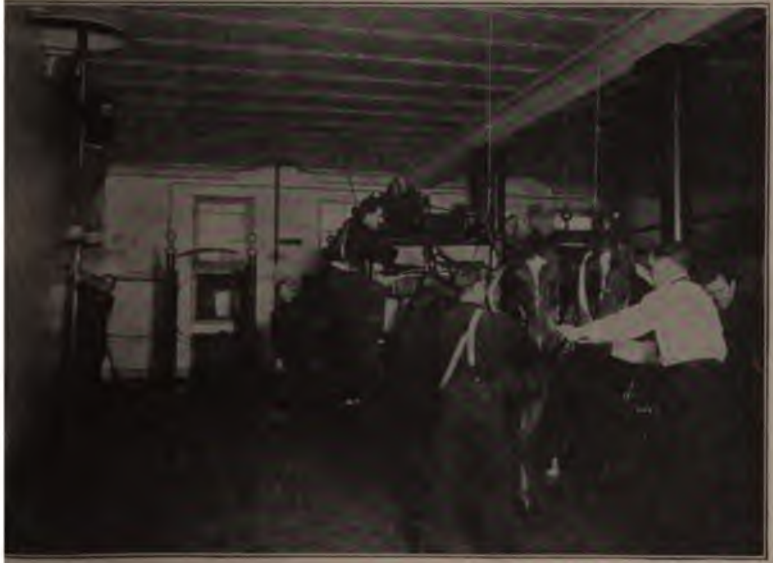


Fig. 224. Making a Quick "Get Away" After an Alarm

t to make them. In some few cases the city has provided apart- ents on the upper floors of the engine house for the accommoda- on of the families of the fire department members. The companies sually require their men to answer to alarms of fire which may occur hile they are at meals. Some cities without such conveniently cated homes for their men; require that they board near enough to spond promptly during meal hours.

EQUIPMENT

The fire fighting apparatus in common use today includes the following variety of fire engines: the horse-drawn and the self-propelled steam engine; the horse-drawn gasoline engine; the motor-propelled gasoline engine; and the chemical engine. Besides these, full equipments have fire boats, high pressure systems, hose wagons, ladder and water tower trucks, fuel and wrecking wagons besides the appliances which are carried with these combinations, such as the requisites for climbing and entering a building, for handling powerful hose streams, etc.

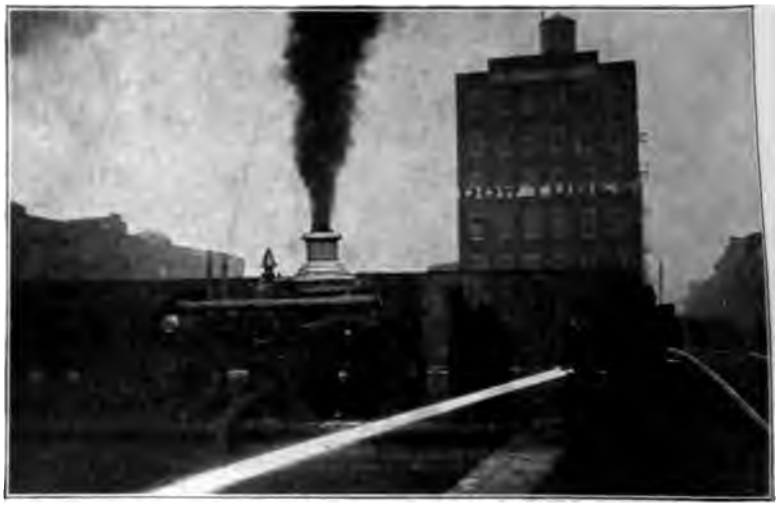


Fig. 225 Fire Engine Undergoing Test for Engine Action and Maximum Water Pressur

Selection of Apparatus. The equipment, which for the leas expense would render the best service in a small town, depend entirely upon local conditions. If there is no water distribution system, then a chemical engine with hose would be best. If there a water distributing system with sufficient pressure to throw hos streams high enough to protect the majority of the buildings, the a hose and ladder equipment is naturally the first thing to be obtained When a town has a water supply system but not under sufficient pressure, then an engine with hose should be the first purchase.

The size of any piece of apparatus selected must be governed

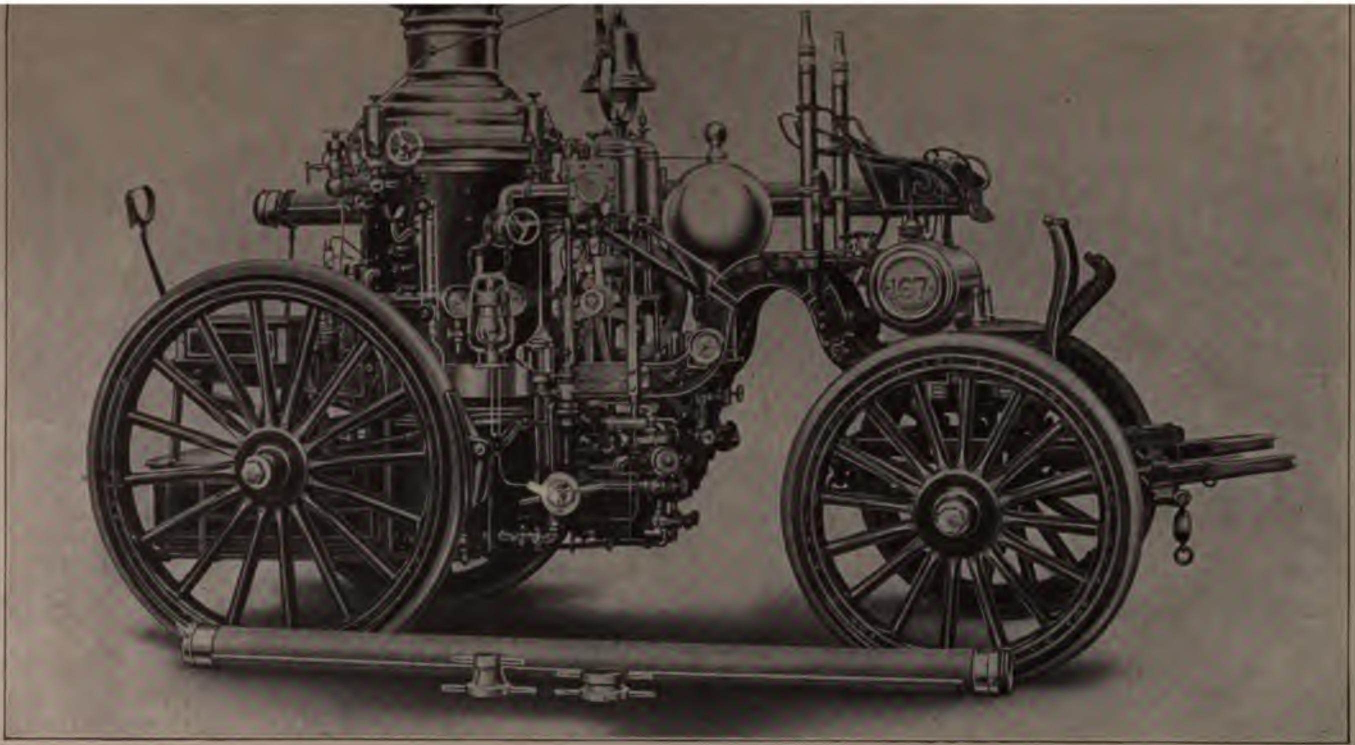


Fig. 226. Metropolitan Steam Fire Engine. Length of Hose Used Between Hydrant and Engine
Courtesy American-La France Fire Engine Company, Elmira, New York

by the character of the work required of it, the means by which it is to be drawn, the condition of the roads, etc.

If it is to be manually drawn, heavy pieces are out of the question for a hilly or sandy country; yet rather than get too small and inefficient apparatus, it might be wiser to delay the purchase until horses could be afforded or motor apparatus bought. Some small towns have horse-drawn apparatus and pay a premium to the first man to have his horse at the fire house after an alarm has rung.

Since two hose streams are required at most fires before a country equipment can arrive, either for extinguishing the fire or for protecting the surrounding property, under usual conditions an engine large enough to furnish at least two good hose streams should be the smallest purchased. All engines should be frequently tested, as shown in Fig. 225, to see that they are in good condition and are keeping up with a reasonable allowance for wear to their rated capacity.

Fire Engines. A typical horse-drawn steam fire engine is shown in Fig. 226. The boilers and pumps used in engines of this type have already been described. Owing to a general lack of skill in running it, and to the rough usage it usually receives on the road, a fire engine can not be expected to keep up to its rated capacity either in discharge or pressure. For this reason a size larger than that which under ideal conditions would do the work should be chosen.

For some time there have been a few self-propelled steam engines in use, but the automobile engine is comparatively new. The firs of the motor apparatus put upon the market was small and light but lately there have developed engines of sufficient capacity to d large city work, Fig. 227, and at present motor apparatus seems to b fast replacing the horse-drawn, although it has the disadvantage introducing the gasoline hazard into engine houses. From a sa tary and humanitarian point of view this substitution is more desi able. The work required of fire horses is arduous and often dange ous, and accidents not infrequently happen to them, while the kee ing of fire horses in the limited accommodations of an engine hou has many objectionable features.

There are numerous decided advantages on the part of the automobile apparatus. For several reasons the cost of maintenance i less. It eliminates the expense of feed and care for the horses; it

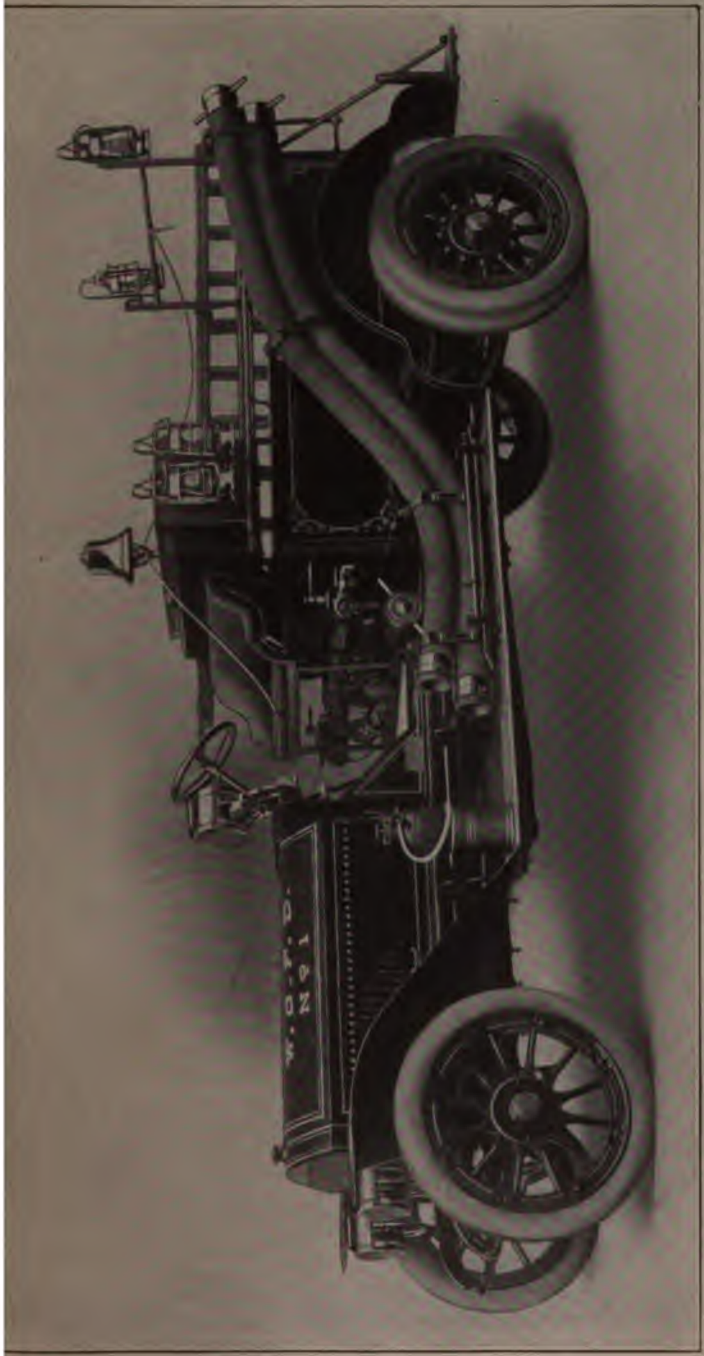
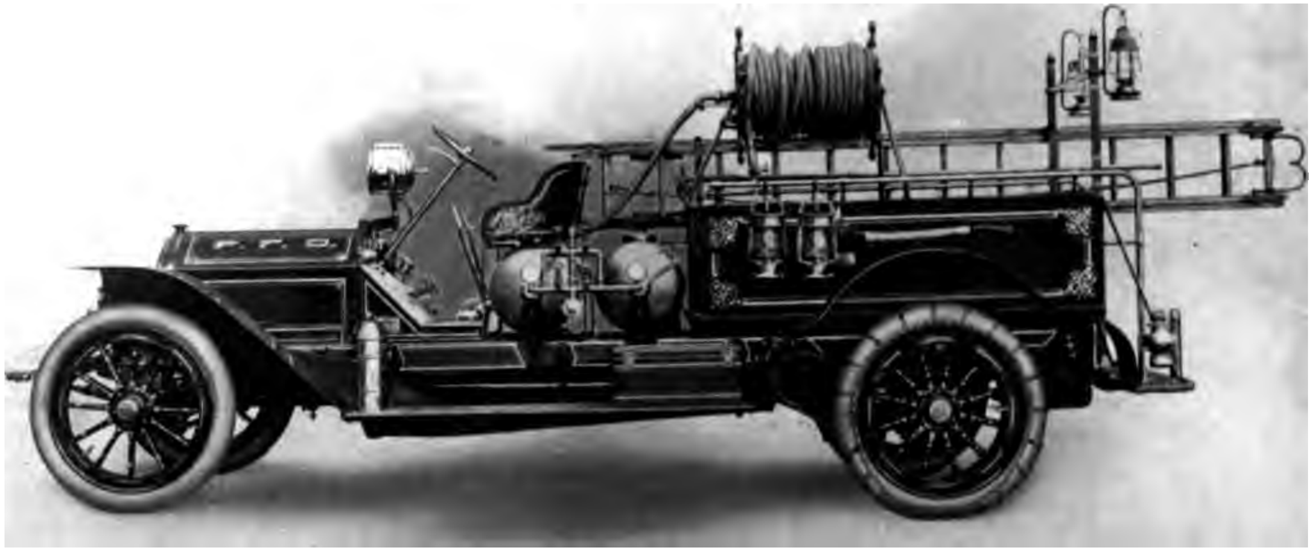


Fig. 227. Combination Gasoline Pumping Engine and Hose Car
Courtesy American-La France Fire Engine Company, Elmira, New York



[illegible] Combination Chemical Engine and Hose Car

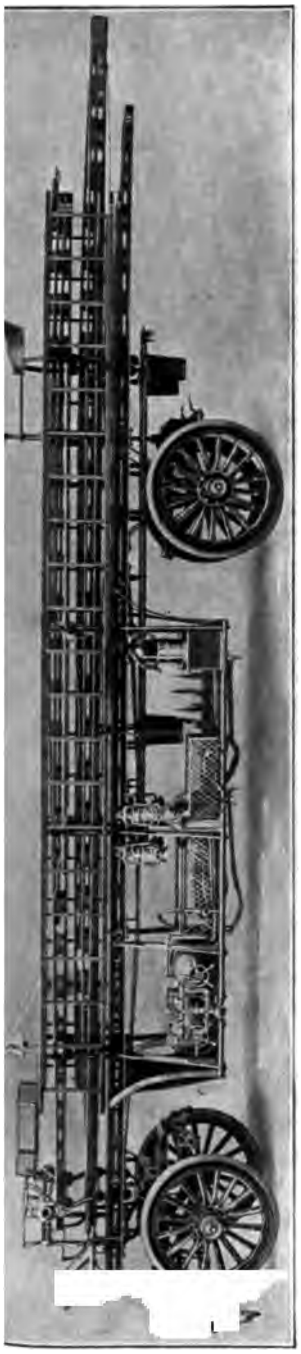


Fig. 229. Thirty-Three Gallon Double Tank Champion Combination Truck
Courtesy American-La France Fire Engine Company, Elmira, New York

requires fewer men to manage a motor equipment for the gasoline engine, since the hose and the ladders may be carried on one truck, requiring but one driver as against three for the equivalent steam equipment; besides this one driver may work as engineer or in some other capacity at the fire. An automobile can travel much more rapidly than can horses and is much more easily managed than they are at the rate at which they travel to a fire. It is ready to leave the engine house without the delays necessary to the horse-drawn apparatus and when once at a fire the power is instantly ready, and the pumps working at their full capacity if that is desired. For hill climbing, for traveling on bad roads, or in snow, the "Auto Engine" has already demonstrated its superiority to horses. In considering all these advantages then —the principal one being that it can reach a fire more quickly than can any other apparatus and thus save time of inestimable value—it is probable that it will ultimately replace horses, at least for city work.

Flying Squadron. With the introduction of the automobile, the flying squadron originated. This consists of a large company of men centrally located and equipped with motor apparatus, principally that of motor chemical and ladder trucks. These men answer all alarms because of the speed at which they can travel. With such an arrangement the scattered companies need fewer men than otherwise. In some cities with but one or a few automobile engines, these are sent out on first alarms, but after the regular horse-drawn apparatus has arrived and is at work, they return to their quarters to be ready to answer other alarms.

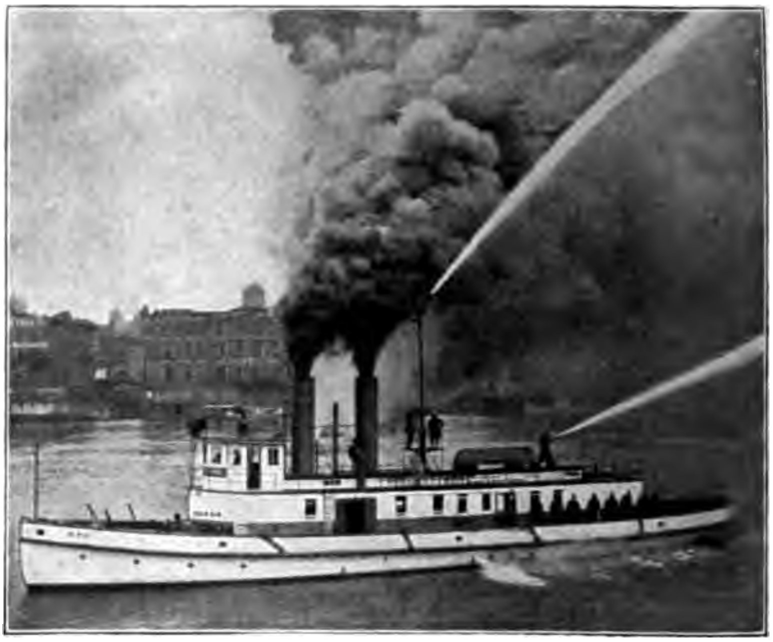


Fig. 230. Fire Boat in Action

Chemical Apparatus. This has already been given a partial description. Chemical engines are very largely used and because of their size and weight they are generally the first piece of apparatus to begin work at fires. They extinguish also a very large per cent of these, it being estimated in some cities as high as 80%. Another great advantage is that they cause but slight water damage.

Originally most chemical engines were separate pieces of the equipment. Now, however, "chemical combinations" seem to be widely favored—that is, a chemical tank of from 35- to 100-gallon capacity is mounted on the hose wagon, Fig. 228, or ladder truck, 229, as said above. Since one of the chief advantages of a chem- engine is that it is light enough to reach a fire quickly, and to be ed about easily when at work, it seems that by increasing its ht or by combining it with anything as difficult of management as der truck, it would eliminate some of its original excellent features.

Fire Boats. As the principal service required of fire boats is ie shallow water along shore, in restricted waterways, and in among the crowded shipping of a city harbor, it is necessary that be designed and constructed to draw but little water and to be readily controlled. A twin screw model has been found best for this purpose. The boats in service, an excellent example of which is shown in Fig. 230, range in size from 80 to 130 feet long and in capacity from 3,000 to 13,000 gallons per minute. Ex-chief Croker of the New York fire department recommends a steel boat 120 feet long over all with 24 foot beam, and 9 foot draft.

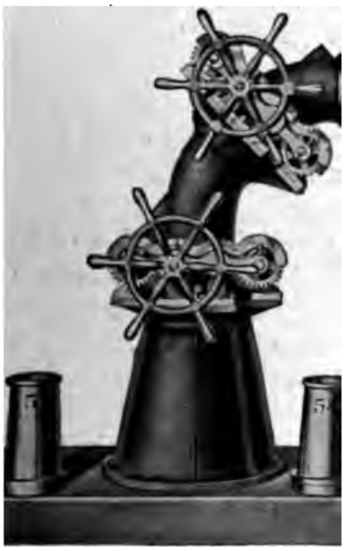


Fig. 231. Turret Nozzles for Fire Boats

umps. On most boats, steam driven reciprocating pumps are and invariably the boiler capacity of the boats has hardly been ent to supply the steam necessary to its engine and at the same o run its pumps at their full rate capacity. Recently a few fire have been fitted with steam turbine driven centrifugal pumps; have given better satisfaction, for with the same amount of greater pump power can be obtained.

ntake and Discharge. The intake on these boats should be ed and designed to be high enough from the bottom to prevent mud in shallow water, and low enough to avoid floating debris.

If the boat is used in fresh water, the boiler feed water may be pumped up; in salt water it is necessary to carry this in a compartment of the boat or in a tank provided for it.

The discharge from the pumps in some cases goes into a water circuit around the boat and hose streams may be taken from this. On other boats there are water turrets, Fig. 231, fitted with hose outlets and valves.

Wharf. Each fire boat near the middle of its district should have a wharf or slip with sufficient shore room to provide quarters for the men. The boat, when not in use, should be moored at this slip, bow out, and with steam constantly up ready to respond instantly to an alarm.

Fire Boat Tenders. Fire boat tenders or hose wagons similar to those for inland use—except that they carry larger hose—are sometimes provided for shore use in connection with fire boat service.

Crew. The officers of these boats should be both good seamen and good firemen. The men usually allowed to a fire boat are a captain, a lieutenant, 2 pilots, 4 engineers, 3 stokers, and 9 firemen.

Fire boat protection has proved of such value, that cities already possessing it have been influenced from time to time to increase the number of their boats. Growing attention is being given to this department of fire protection, for it seems a well nigh indispensable defense for large cities bordering on the water.

Ladder Trucks. The height of the buildings to be protected must govern the length of the fire department ladders. In small cities and in towns where but few buildings are more than three stories high, the plain hand-managed ladders will usually be all that is necessary. Trucks containing these plain ladders may be had in many sizes, from the small set suited to a village hand-drawn apparatus, to the large trucks holding ladders up to 65 and 75 feet in length, for city use. Yet where such lengths as these are necessary, or wherever buildings of more than three stories are the rule rather than the exception, so-called aerial ladders should also be included in the equipment. The ladders, when extended, Fig. 232, measure up to 75 and 85 feet. They are attached at their foot to the truck, from which they are raised by springs, pneumatic pressure, hydraulic pressure, screws, or chains.

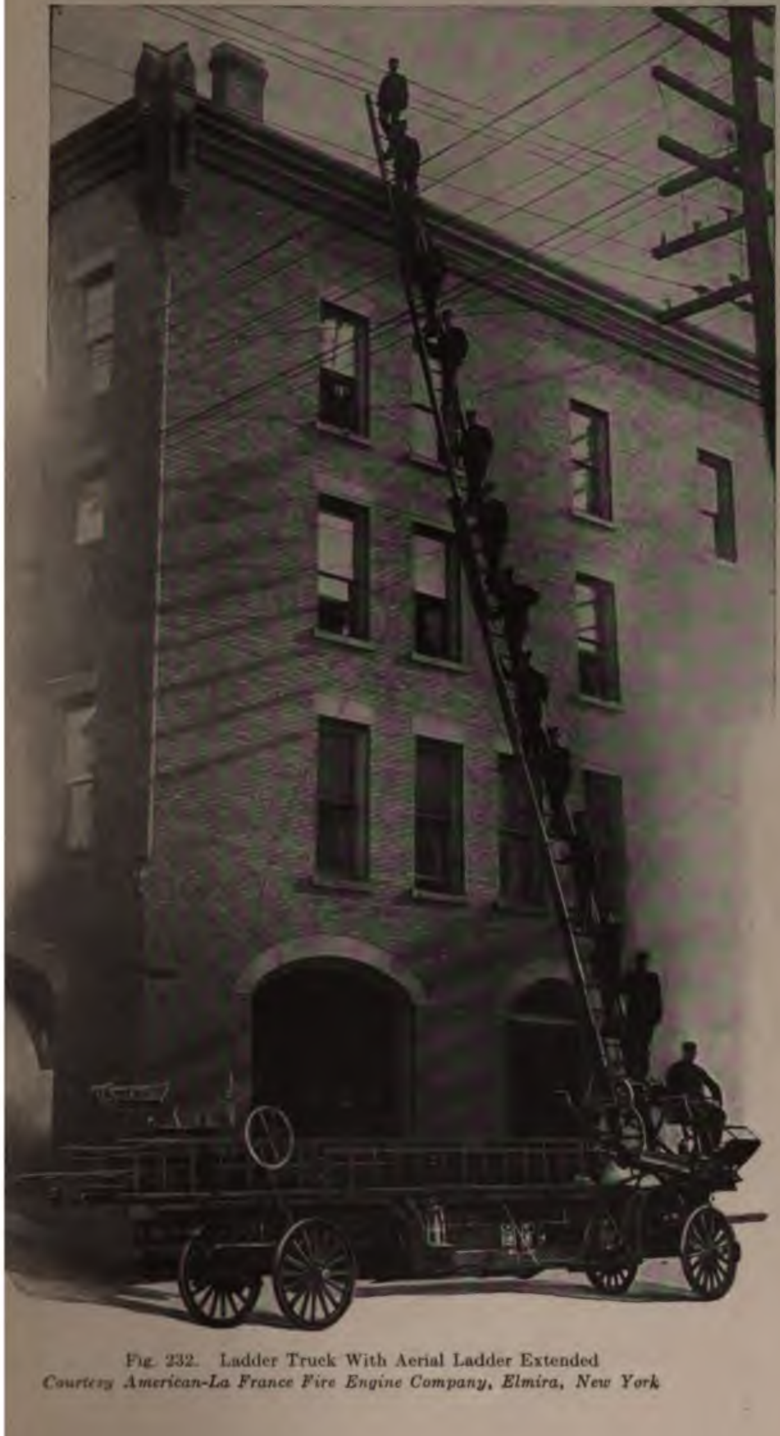


Fig. 232. Ladder Truck With Aerial Ladder Extended
Courtesy American-La France Fire Engine Company, Elmira, New York

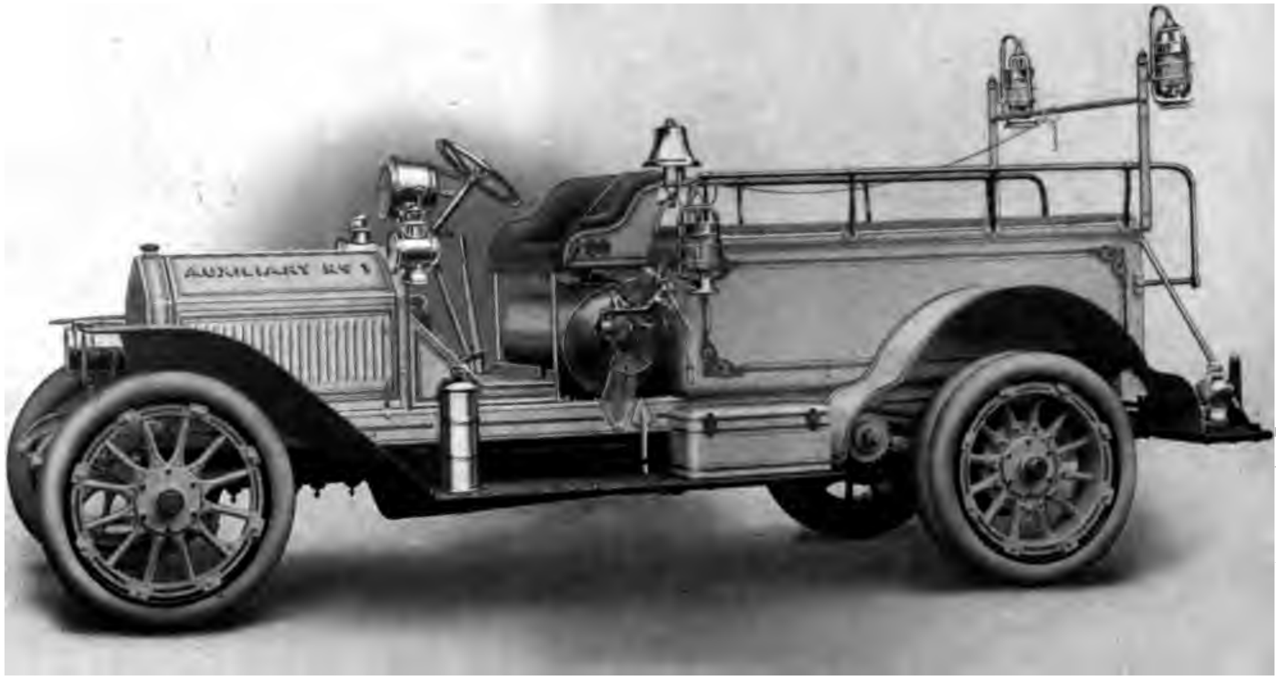


Fig. 233, Combination Chemical Engine and Hose Car with Square Body

Courtesy American-La France Fire Engine Company, Elmira, New York

Ladder trucks often carry as high as 14 or 15 ladders arranged ither in a box-like receptacle (box truck) or on a frame work (skeleon truck).

In fire fighting, laders are used not only to each upper floors, but as attering rams, bridges from ue building to another cross air, light, and other hafts, for either pushing ver or for supporting danrous or loose walls, for olding hose in a high posion, etc.

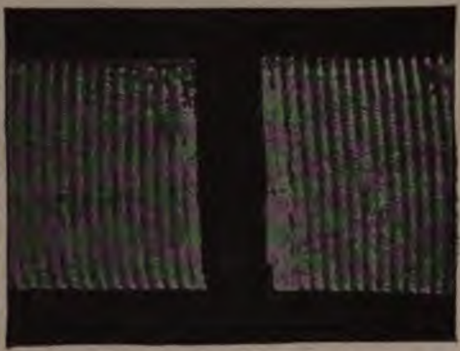


Fig. 234. Plaster Cast of Interior Surface of Poor Rubber Lined Hose

Courtesy Inspection Department, Associated Factory Mutual Companies, Boston, Mass.

Besides the ladders, hese trucks often carry a. hemical tank, as already hown in Fig. 229. Lanterns, ropes, and portable extinguishers re an important part of their equipment. Besides these they ay carry any of the following: nozzles of all kinds, axes, plaster ooks, door openers, augers, rams, saws, mauls, picks, hammers, iisels, roof and wire cutters, window smashers, acetylene torches, ickets, life nets, hose reair kit, rope gun, smoke ammonia helmets, rubber oves, megaphones, surcal kit, etc.

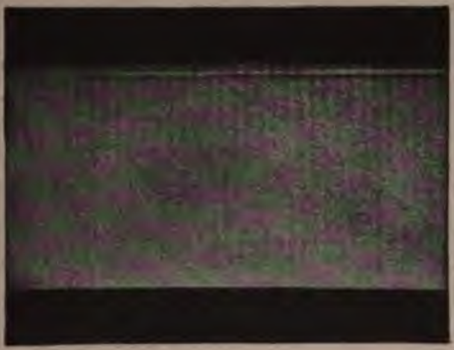


Fig. 235. Plaster Cast of Interior Surface of Good Rubber Lined Hose

Courtesy Inspection Department, Associated Factory Mutual Companies, Boston, Mass.

Hose Wagons. Until cently hose was kept on ls, but it has been found at folding it back and th in boxes is not only a re compact way of storit, but that it has the ther advantage of allowthe hose to be more ily pulled out. Experience has shown that this way of packing loes not undesirably affect the wear of the hose, and the National

Board of Fire Underwriters has, therefore, recommended the use of box hose wagons in place of the reel type. Fig. 233 shows a combination auto chemical engine and hose car.

Hose. The importance of good fire hose needs no argument. Nearly every one is familiar with reports of fires where bursting hose made the firemen nearly helpless or at least greatly increased the difficulties of their work. Much of the hose now on the market contains inferior material or is dishonestly made. For example, Figs. 234 and 235 show plaster casts of the interior surfaces of two kinds of rubber lined hose. The loss of pressure due to rough surface of the first is 25.5 pounds per 100 feet of hose, while the loss with the better hose is only 14.1 pounds per 100 feet. Fire departments use rubber lined hose covered either with a cotton jacket or by a cotton rubber covered duck. The first kind—that which has the cotton on the outside is more durable, more flexible, and therefore more easily managed than the other variety. This hose, however, has to be dried each ti[illegible] it is used to prevent mildew and rot, while rubber covered hose ne[illegible] not be. Where it has considerable usage, the life of the cotton cover[illegible] hose is about seven years and that of the rubber covered about fi[illegible]

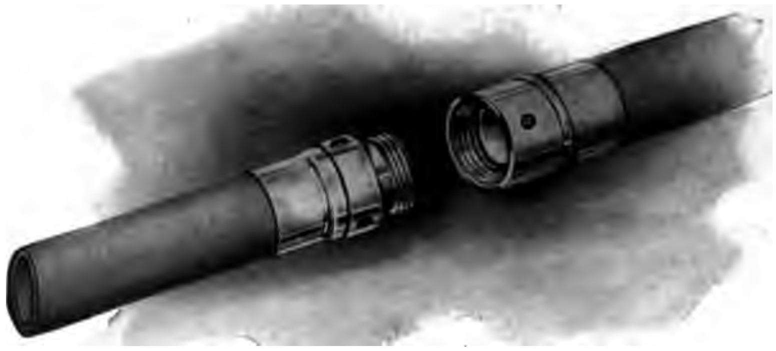


Fig. 236. Typical Screw Hose Couplings
Courtesy American-La France Fire Engine Company, Elmira, New York

Sizes. Fire departments use mostly hose of 2½-inch inter[illegible] diameter, since this is the size most easily managed; although [illegible] saving of friction head with a 3-inch hose is so great that it is be[illegible] used by many city companies who find it often necessary to h[illegible] long lines of hose. This size gives good outside service but [illegible] inside use the 2½-inch or the standpipe hose is the more useful. With the same hydrant pressure, 3-inch hose will deliver a stream of water twice as far as a 2½-inch hose, and give the same nozzle pressure. The saving by using two lines of hose and connecting them by a siamese connection back of the nozzle has already been treated. A line of 3½-inch hose will give approximately the same results as two parallel lines of 2½-inch hose.

Standard Couplings and Hose. The hose couplings used are generally of the screw type, Fig. 236, although there are patented snap couplings which have found some favor. Because of the variety of sizes and makes in use the apparatus of one city can seldom connect with the hydrants in another. For this reason, outside apparatus called to aid in a conflagration or a large fire is often found useless. Efforts are being made to establish uniformity in couplings by urging all cities and towns to adopt the couplings selected as the National Standard. This standard coupling has 7½ threads to the inch and measures 3⅙ inches in diameter outside the male thread.

The National Board issues specifications for standard 2½-, 3-, and 3½-inch hose for fire department use. Several makes of such hose have passed satisfactorily the tests at the Underwriters' Laboratories and bear their labels. During the manufacture of approved hose, inspectors from the Underwriters' Laboratories may visit the factories at any time to inspect the materials and processes used, and they may take samples to the laboratory for further tests. In spite of all precautions, however, the findings of a committee on fire department hose in 1911—after testing and examining 28 different brands, including 33 different samples collected from fire departments all over the country—were most unsatisfactory and seemed to show that even more rigid requirements, especially for the materials used, are needed.

NATIONAL BOARD REQUIREMENTS FOR FIRE DEPARTMENT HOSE

The National Board of Fire Underwriters requires that the rubber composition used for the inner tubes contain at least 40 per cent of pure new rubber, and that it contain no injurious ingredients. The breaking strength of this lining must not be less than 800 pounds to the square inch, and the length at the breaking point ought not to be less than four and one-half times the initial length. If a 2-inch section is taken and stretched to 9 inches, and held so stretched for ten minutes, and then released, it should contract within the next ten minutes to at least 2¾ inches.

The cotton used in the covering should be of long staple (at least one inch is suggested) and the woven fabric should show no injurious or unsightly imperfections.

The cement between the inner tube and outside fabric should be of such good quality as to assure secure adhesion and durability.

Every fifty feet of hose should bear twice the name of the manufacturer, and the year and month in which it was made, stenciled in black letters one inch high.

The manufacturer must test every length of hose after coupling, but before delivery, to see that the couplings are properly attached and that the hose has no imperfections.

(a) This hose test should be under the following pressures for cotton covered hose:

Single jacket	200 pounds
Two jackets or plies, separate or interwoven	300 pounds
Three jackets or plies, separate or interwoven	300 pounds

Hose should be carefully dried before shipment.

(b) One length of hose in every twenty (20) or fraction of this number, shall be subject to the following pressure tests:

Single jacket	350 pounds
Two jackets or plies, separate or interwoven	450 pounds
Three jackets or plies, separate or interwoven	450 pounds

For duck-covered hose the test pressure should be 300 pounds, and one length out of every twenty should be tested to 400 pounds.

Under these tests there should be no excessive tendency to twist or writhe, nor any excessive elongation or increase in diameter.

Care of Hose. The National Board gives the following cautions to all officials and to those responsible for the care of hose:

(1) To run water through all hose at least four times a year, but to drain the hose carefully before stowing away again. With cotton jacketed hose, to allow fabric to dry thoroughly.

Note: This applies particularly to small departments where hose receives infrequent use.

(2) To avoid keeping hose in warm rooms.

(3) To keep spare hose either stretched out or rolled up, avoiding as far as possible kinking or bending it. Slanting ventilated racks are advised.

(4) To test it once a year to a pressure of 200 pounds, where subject to considerable service, and in all cases not less than 150 pounds.

Fuel Wagons. In the case of serious fires or those of long duration, it is essential that there be a definite and thoroughly understood manner of replenishing the fuel supply for the engine. Usually the engine, the hose wagon, or the truck driver returns with his horses to the fuel station and brings back the fuel wagon loaded with cans or sacks of the coal.

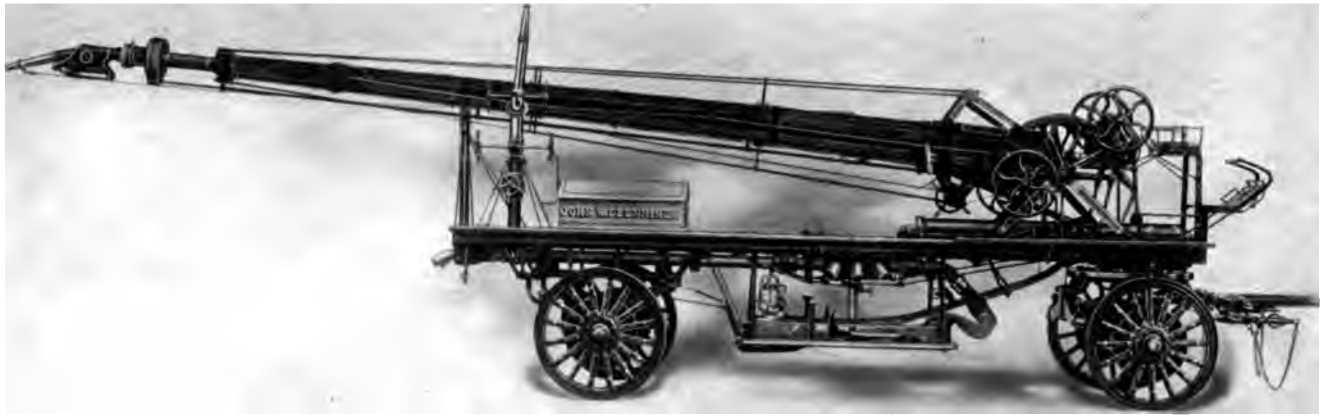


Fig. 237. Automatic Water Tower. Standard Equipment: Deck Turret, Nozzle Tips, Hose, Hose Straps, Tool Box, Wire Basket, Gong, Lanterns, Axes, Crowbar, Oil Can, Wrenches, and Cranks

Courtesy American-La France Fire Engine Company, Elmira, New York

Portable engines are sometimes used for generating the power to supply an attached electric arc search light used to penetrate the smoke or darkness. This apparatus is cumbersome and in the majority of cases the hand acetylene torch or search light is used by the firemen in searching for companions or fire victims; in avoiding such dangerous places as light, elevator, and other similar shafts; and in finding their way about generally through the darkness and smoke.

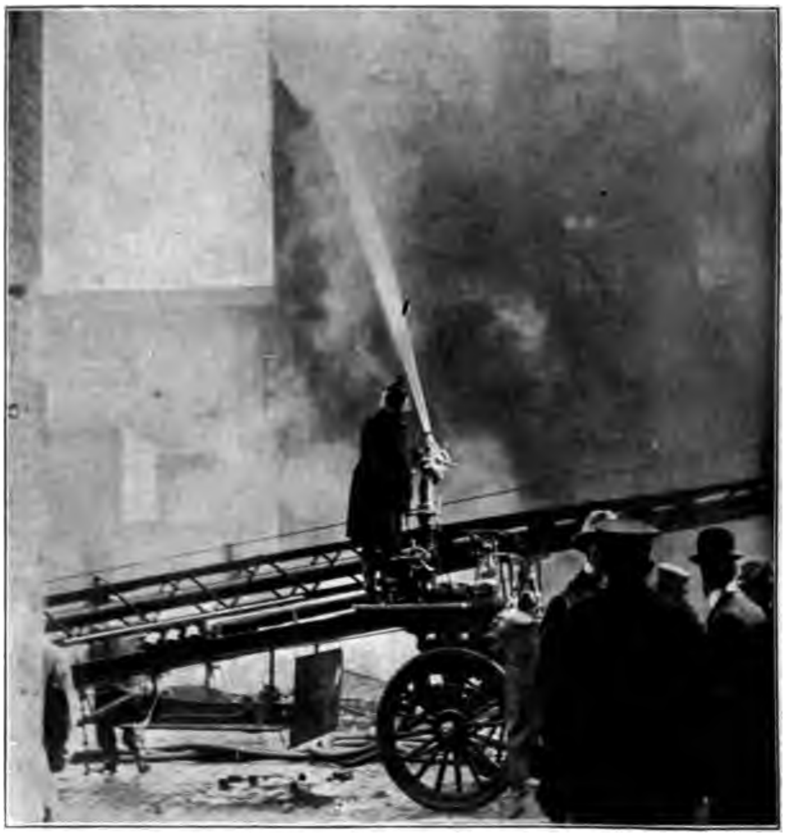


Fig. 238. Hose Stream from Turret Nozzle on Water Tower Truck

The fire departments of the many large cities often have some piece of apparatus not in general use, such as wrecking engines, equipped with wrecking appliances, tools, etc., which may be needed at large fires, coffee wagons for refreshing the firemen while on duty, etc.

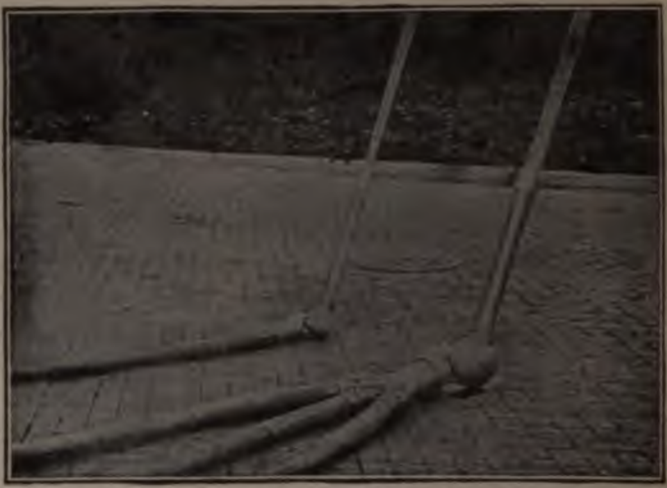


Fig. 240. Universal Turret Nozzles*

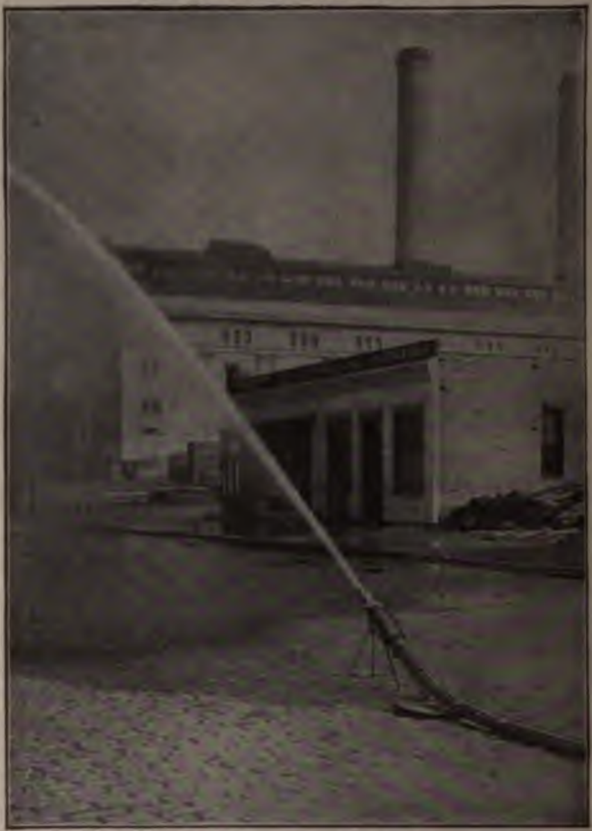
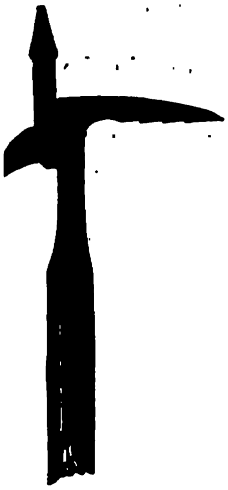


Fig. 241. Eastman Stand for High Pressure Streams*

**Courtesy American-La France Fire Engine Company, Elmira, New York*



ig. 242. Plaster Hook*

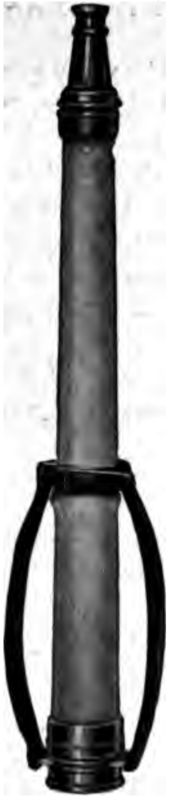


Fig. 243. Rubber Play Pipe*

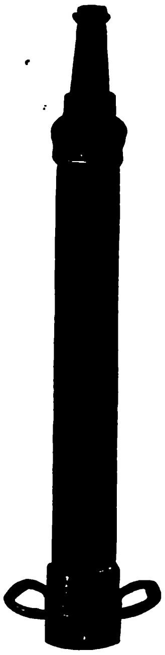
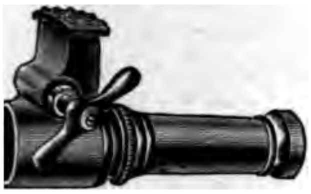
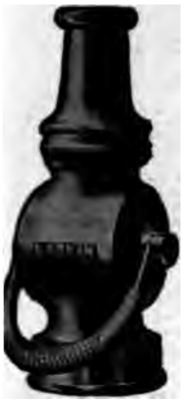


Fig. 244. Flexible Play Pipe*



g. 245. Ashworth Shut-Off Nozzle*



ig. 246. Larkin Shut-Off Nozzle*

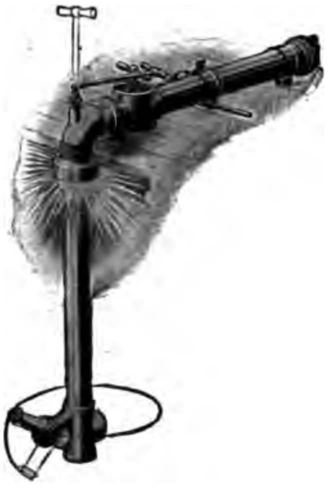


Fig. 247. Hart Cellar Pipe with Shut-Off Valve*

**Courtesy American-La France Fire Engine Company, Elmira, New York*

so that when turned to any position they will remain th voluntarily directed elsewhere.

Time Savers. Besides providing the equipment as enu cities spend thousands of dollars to install and maintain de saving time such as the electric fire alarm system; the harness, Fig. 251, which drops into position on the horses patented collar snaps and strap locks, Fig. 252, for quick a the automatic release, Fig. 253; the sliding poles, Fig. 25

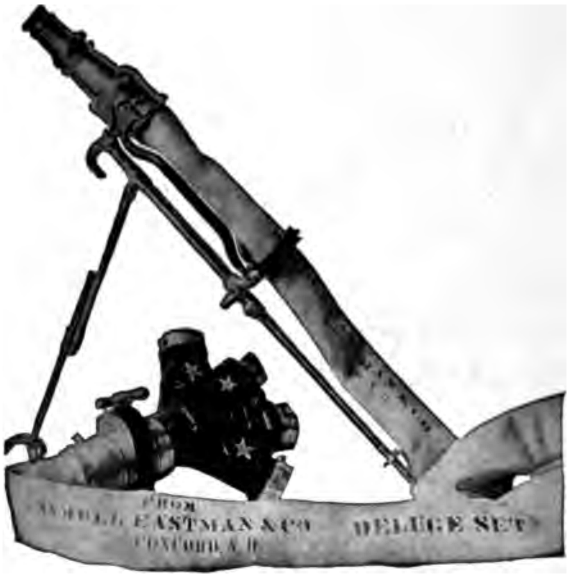


Fig. 248. Eastman Deluge Set
Courtesy American-La France Fire Engine Company, Elmira, New York

matic engine house and stable door openers, Fig. 255, etc., last though greatest time saver, the automobile apparatus.

Fire Alarm Systems. *History.* Mention has alrea made of the watch tower system of fire alarms which, un was the best alarm system in use. This method obtained its development in New York City which as early as 1845 was into districts with a watch tower in each. Watchmen were at all hours. When any one of them discovered a fire or reported to him he struck upon the tower bell the numbe district. This was heard and repeated by the watchmen in other towers, so from counting the alarm any one could know in what district the fire was.

As early as 1845 a Dr. Channing of Boston published an article on the transmission of fire alarms by the then new telegraph, and by 1852 Boston had installed the first fire alarm telegraph system

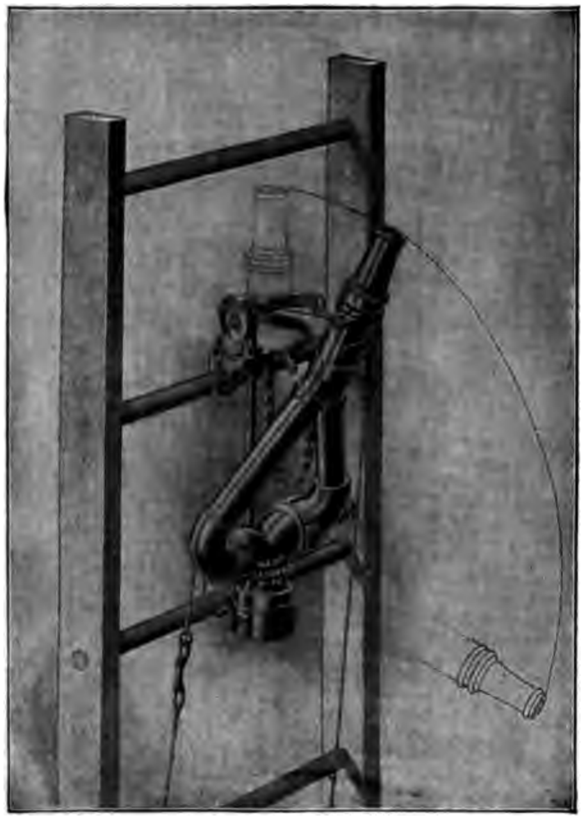


Fig. 249. Hart Ladder Pipe
Courtesy American-La France Fire Engine Company, Elmira, New York

It is surprising that this method of sending fire alarms was not more rapidly adopted, since in the first twenty years following its invention only about twenty cities had adopted it. At the present time, however, nearly every large city and town of importance has some form of telegraphic fire alarms.

Street Boxes. In all such systems the operation of the street box is generally the same—that is, the pulling down of a hook or lever. In some cases in order to reach the hook, the outside door of the alarm box must be unlocked, Fig. 256, by a key kept by the police and by some reliable resident or storekeeper nearby. The delay caused by hunting for the key, however, is such an objection that in some types, Fig. 257, the key is kept in the lock, covered over by a box having a glass door, Fig. 258, and is thus accessible by breaking the glass. Such precautions are usually unnecessary, and in most large places the keyless or unlocked boxes, Fig. 259, are used. In older forms of this type there was an arrangement by which a gong or bell inside the door rang when the box was opened, thus attracting the attention of the police and of passers-by to the person doing it. This method proved objectionable in that, with the ringing of the gong, people often thought that the alarm had been turned in and went away without pulling the real central station alarm. In the form shown in Fig. 259, the opening of the door not only rings a gong to attract attention, but actually does operate the central station alarm devices.

Fig. 250. Hart Turret Pipe
Courtesy American-La France Fire Engine Company, Elmira, New York

The mechanism of the box consists of an irregularly toothed wheel which in revolving breaks and closes an electric circuit. The irregularities in the closing and the breaking of the circuit designate at the central office the number of the box pulled.

By a complex arrangement this indicating wheel when once started to revolve can not be stopped, or interfered with by repeated pulls on the hook or in any other way, until it has

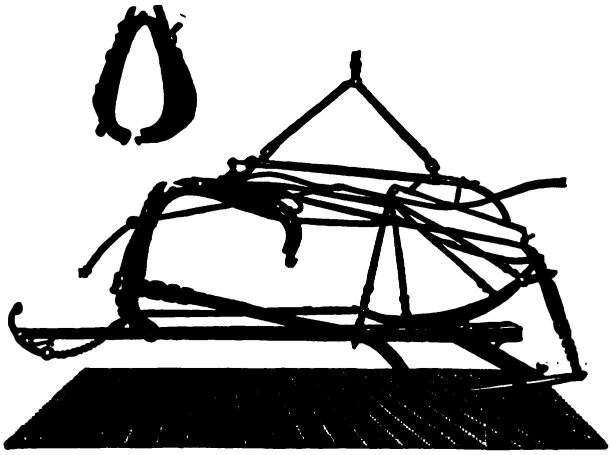


Fig. 251. Swinging Fire Harness*

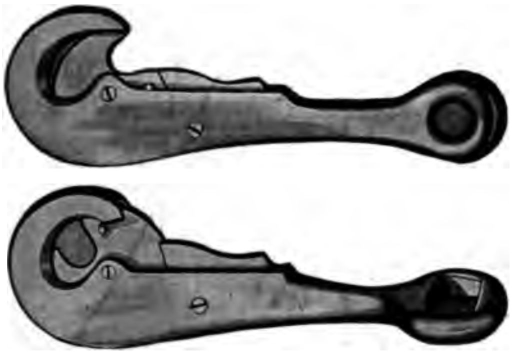


Fig. 252. Walsh Safety Lock Snaps*

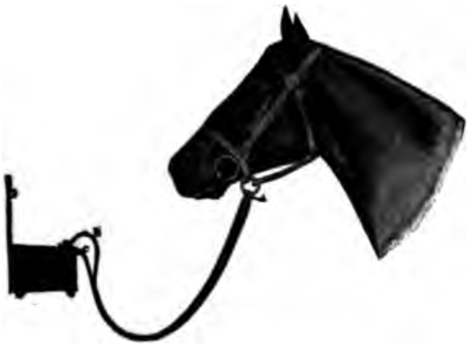


Fig. 253. Hale Automatic Electric Release Trip*

**Courtesy American-La France Fire Engine Company, Elmira, New York*

completely finished the revolutions necessary to transmit the alarm.

This box mechanism has to be kept within dustproof and weatherproof boxes, fitted with lightning arresters and protected against electric currents of high potential such as are used for light and power. Besides the alarm devices, each box contains a telegraphic key and call bells for engineers or police signals.

Central Office. The alarm from the street box is conveyed through wires or underground cable to the central office, Fig. 260, where it causes the box number to be tapped on a gong and at the same time to be automatically registered by a triangular punch in a strip of paper, Fig. 261, the point of the perforation always indicating the direction in which the signal had been received.

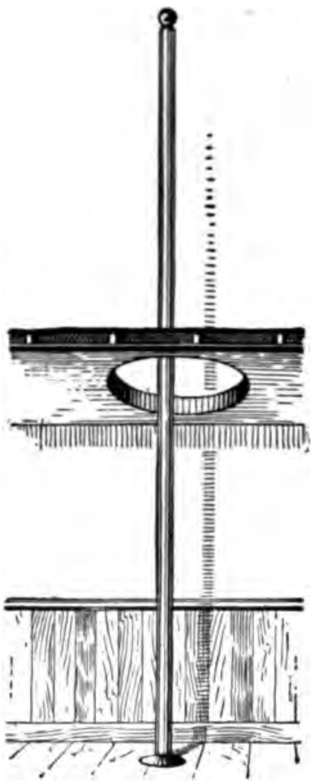


Fig. 254. Sliding Pole*

The central station operator, by turning a lever, then connects the box circuits shown on the register to the alarm circuits and instantly the number of the box from which the alarm came is registered on tape and tapped out on a gong at all the engine houses on that circuit. By the setting and the operating of another device, the number of the alarm box is shown visibly on an indicator and at the same time tapped out on a large gong at the engine house, Fig. 262. In this manner all the alarms

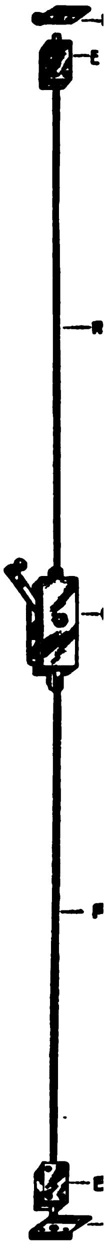


Fig. 255. D-Spring*

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*Courtesy American-La France Fire Engine Company, Elmira, New York to the engine houses are sent over two different circuits, and are registered and rung on two sets of instruments, thus eliminating all probability of mistake.

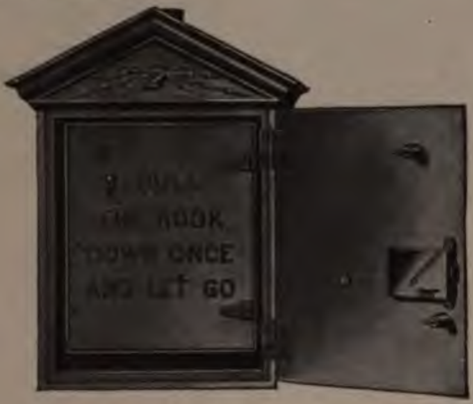

Fig. 256. Standard Fire Alarm Box, Open*

After sending the alarms, the operator punches numbered keys show which engine companies will respond to this first, second, or

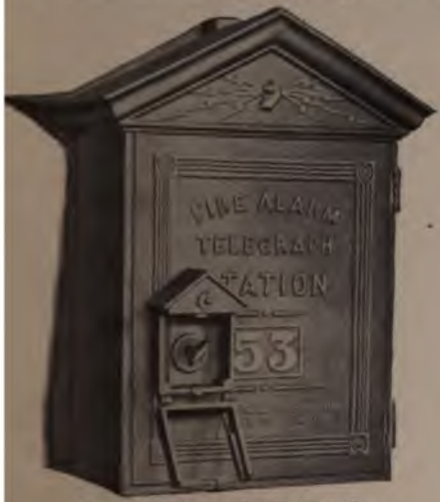

Fig. 257. Standard Fire Alarm Box with Key Guard*

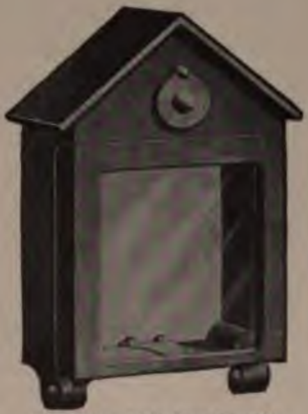

Fig. 258. Cole Key Guard*

reater alarm of fire. The central office is notified when any com-
any returns to their quarters. By this means the central office

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*Courtesy Gamewell Fire Alarm Telegraph Company, New York has at all times a record both of the companies that are in and those that are out.

Besides these devices which have been roughly described, a complete fire alarm system includes many others, such as "line testers" which keep check on the condition of all circuits, and devices for keeping one alarm from interfering with another coming in on the same circuit especially when several alarms are sent for the same fire.

Small City and Town Alarms. In small cities an automatic repeater, Fig. 263, instead of an operator may be employed for sending out the alarms which are received at the office. By this device whenever an alarm is received, it is automatically sent out to every engine house. In large cities the repeating of every alarm to every engine house would be useless and confusing; so the operator is employed to see that alarms are sent only to the engine houses near the fire.

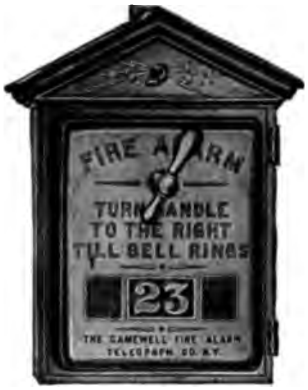
FIRE ALARM
TURN HANDLE TO THE RIGHT TILL BELL RINGS
23
THE GAMEWELL FIRE ALARM TELEGRAPH CO. N.Y.

Fig. 259. Keyless Door Fire Alarm Box

Courtesy Gamewell Fire Alarm Telegraph Company, New York

For towns, there is an automatic system that gives a general alarm by automatically striking on a gong or on the church or school bell, Fig. 264, or by blowing whistles, Fig. 265, to indicate the number of the district from which the alarm was sent.

Auxiliary Alarms. The delays, often occasioned by the necessity of going from the upper stories of high buildings to the street boxes which may be a block or two away, may be obviated by the installation, within the building, of auxiliary alarm boxes. By pulling the hook in these, the nearest street alarm box is set in operation and the alarm transmitted.

NATIONAL BOARD REQUIREMENTS FOR ALARM SYSTEMS

Alarm Boxes. For cities the National Board of Fire Underwriters recommend keyless boxes to be so located that in the mercantile and manufacturing districts it will not be necessary to go over 400 feet in order to reach one. In the closely built-up residential district it should not be necessary to

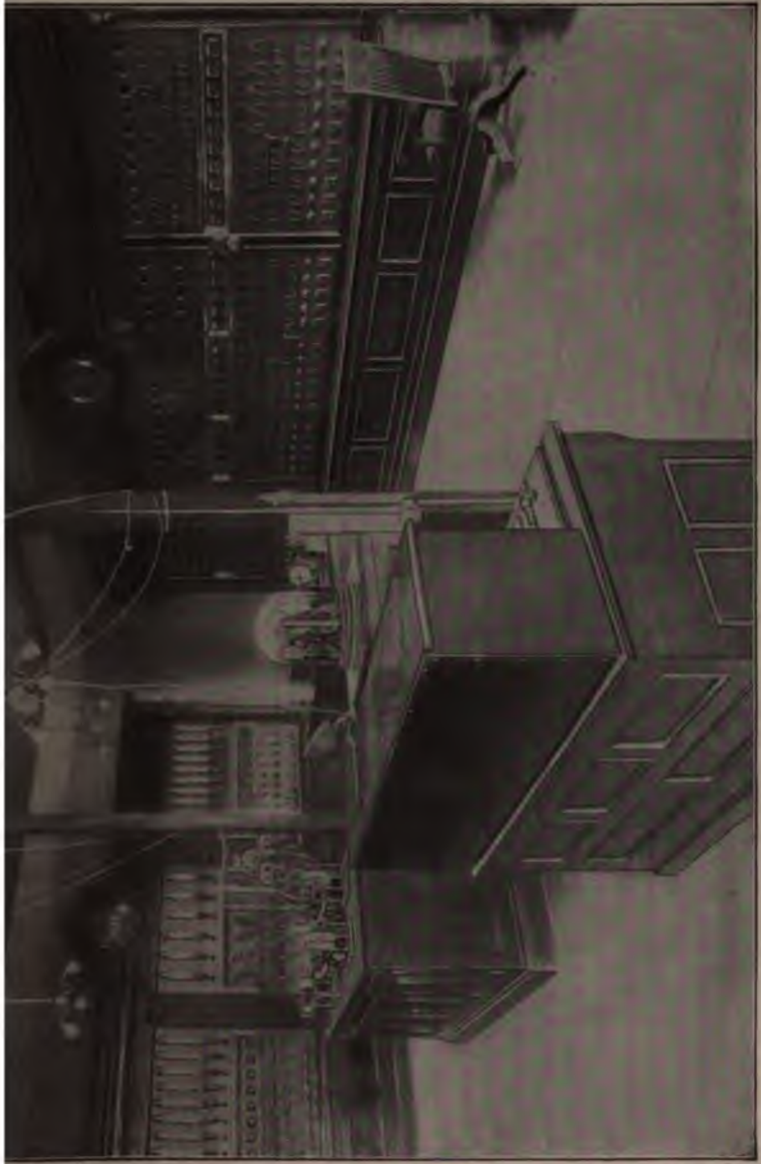

Fig. 260. Central Office of Fire Alarm System
Courtesy Gamewell Fire Alarm Telegraph Company, New York

go more than 800 feet, and in the outlying residential districts not more tha
1,200 feet to a box.

In order to be conspicuous, these alarm boxes should be painted red; i
they are mounted on a pole, the pole should be marked by a red stripe. A re
light should denote their location at night.

Central Office Building. The central office building of a fire alarm sy
tem should have every possible protection against damage by fire. For th
reason it should be located so as to be unexposed for at least 150 feet on a
sides. In cities the best site would be in some park or reservation. The buil
ing itself should be of fireproof construction and, according to the Nation
Board recommendations, there should be no wood used in its construction-
not even for "top flooring, window or door trim, closets, instrument cases, etc.

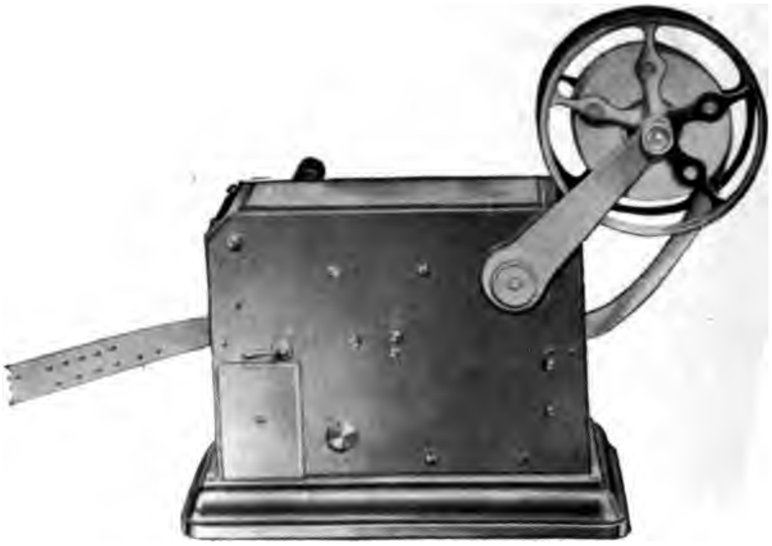

Fig. 261. Multiple Circuit Puncturing Register
Courtesy Gamewell Fire Alarm Telegraph Company, New York

The electrical apparatus should be installed and kept in condit
men known to be competent for the work.

Concerning all points of a fire alarm system, it should be co
remembered that any defect, neglect, or oversight, may result in a
expense to the city than would have been incurred by the installatio
feet devices with skilled operators.

HIGH PRESSURE SYSTEMS

Fire Fighting Problem in Big Cities. The term "High
Systems," as here used, refers to all systems especially de
and devoted to supplying water for use at fires under a s

high pressure to furnish satisfactory hose streams for severe service directly from the hydrants, Fig. 266, without the interposition of fire engines. The principles governing pressure in water, the distribution of water, etc., as set forth in "Fire Insurance Inspection," Part IV, are all applicable to these systems of distribution.

The use of high pressure systems for fighting fires is not new, although only recently has their installation become common. In some of our large cities, such systems have become well nigh imperative in consideration of the public safety; and their use in small cities is often a matter of combined convenience and economy. The limit in weight and bulk of fire-fighting apparatus has very nearly been reached. In congested districts, especially where the streets are narrow, the rate at which the fire engine must travel and the accompanying excitement make its passing a source of danger both to pedestrians and traffic. The advantage of a high pressure system in eliminating this cumbersome apparatus in such districts is obvious. A further reason for the speedily increasing number of these systems is found in the rapidly growing height of our buildings and the general inadequacy of the regular water supply system—either from too small pipe sizes or because of a limited source—to cope with large fires.

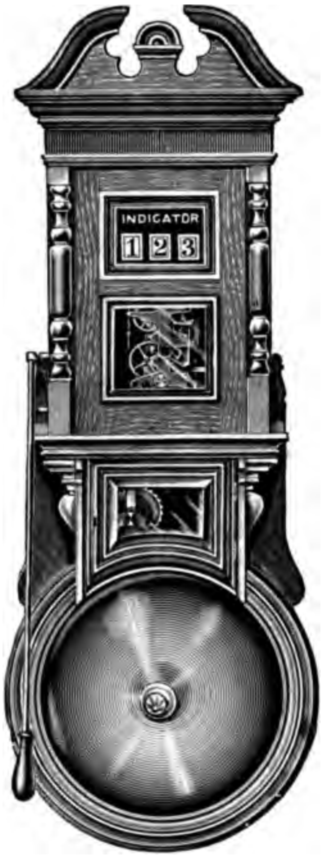

Fig. 262. Combined Gong and Indicator
Courtesy Gamewell Fire Alarm Telegraph Company, New York

Fifteen years ago the World Building of New York was one of the highest buildings in this country. Today in that city there are several forty- to forty-eight-story buildings which stand out no more noticeably from their surroundings than did this once high structure. In many other cities the same relative growth has been shown.

In spite of the tremendous development of fire-resisting construction and fireproof material, which have made such high buildings possible, the fire hazard has increased at a much more alarming rate than has the height of the buildings.

It is estimated *that the difficulty of fighting fire in a building increases in proportion to the square of the building's height.* Therefore, to obtain the same degree of protection to the high building that was afforded to the smaller, the fire-fighting facilities should be increased many fold. This, however, has never been the case; in fact, the opposite conditions too often exist. A city grows territorially, the business districts become congested, and the buildings consequently become higher and higher. The result of all this is that the original water supply system, whose capacity is often reduced by corroded pipes, becomes less and less adequate, while the margin for fire purposes above the domestic consumption becomes proportionally smaller and smaller.

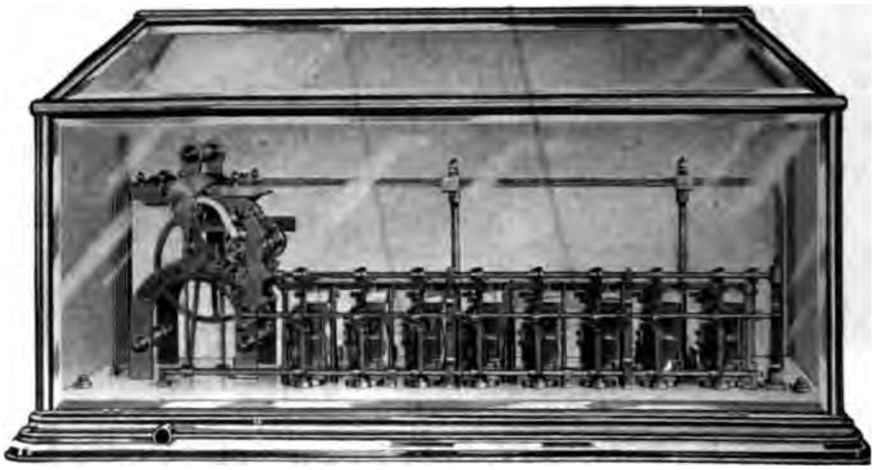

Fig. 263. Multiple Automatic Repeater
Courtesy Gamewell Fire Alarm Telegraph Company, New York

In any of these cases it is most often more economical and satisfactory to obtain the desired increase of pressure and volume by supplementing the original supply by a high pressure system rather than by enlarging the entire waterworks system.

Pressure and Quantity of Water Required. A pressure sufficient in one city would be quite inadequate in another. Therefore, in the so-called high pressure systems in use now, we find the maximum hydrant pressures varying from 100 to 130 pounds in one city, and to 200 to 235 pounds in another.

Wherever these systems are used, they are provided for and looked upon as the chief defense against a conflagration; thus besides furnishing water at high pressures, they should be able to furnish a vast quantity of water for an extended length of time. One authority states that the minimum available quantity from the outlets of a high pressure system should be enough to supply the service in its full efficiency for at least thirty-six hours; that under the least exacting conditions it should be able to furnish about eighteen 1¼-inch streams

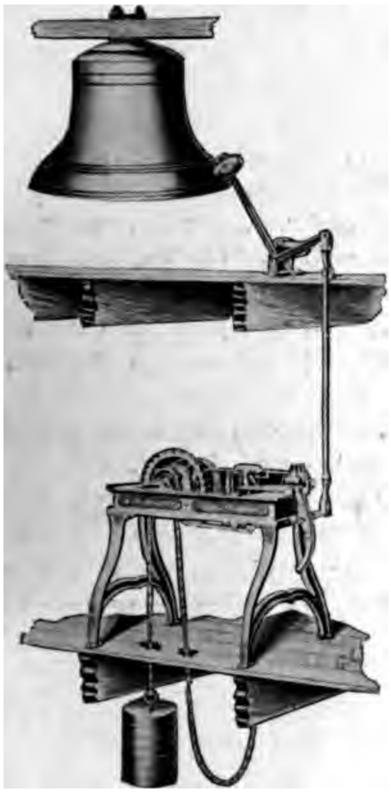

Fig. 264. Bell Striker Mounted on Bell*

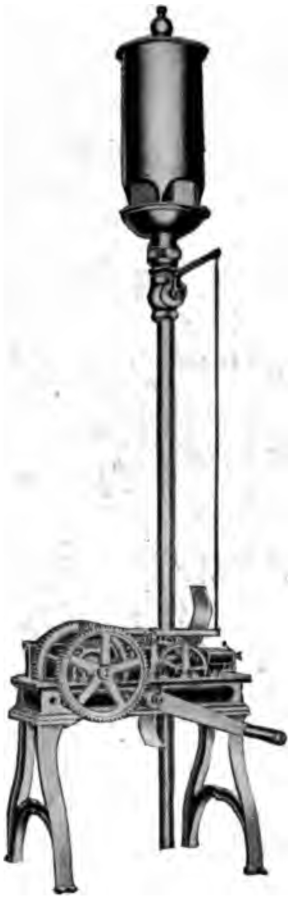

Fig. 265. Whistle Machine Showing Mechanism*

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*Courtesy Gamewell Fire Alarm Telegraph Company, New York

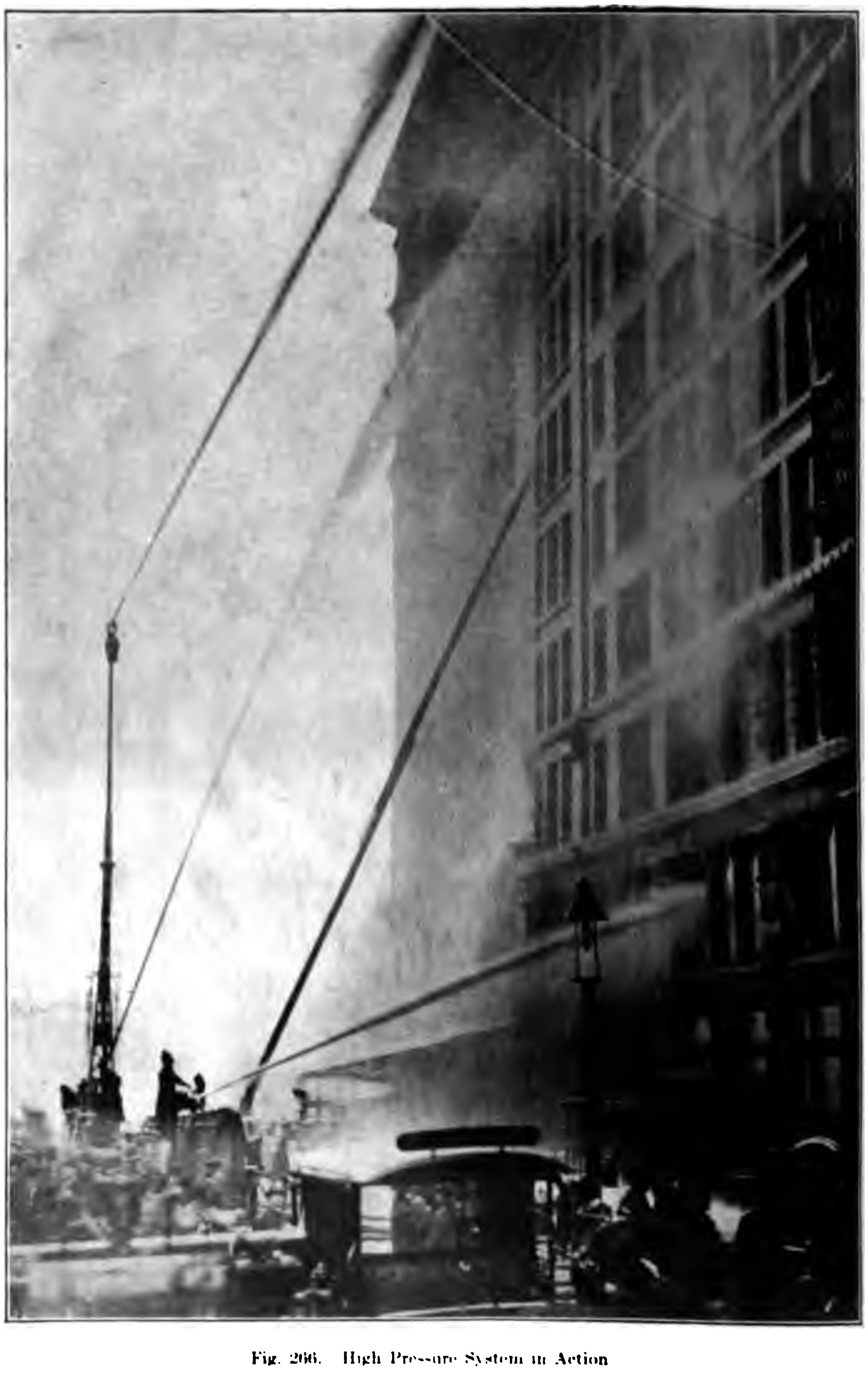


Fig. 266. High Pressure System in Action

or seven 2-inch streams, or the equivalent of 7,500 gallons per minute; that in cases of more exacting local fires it should be able to supply 20,000 gallons per minute or the equivalent of fifty $1\frac{1}{4}$-inch streams or twenty 2-inch streams; and that it is advisable to leave a sufficient

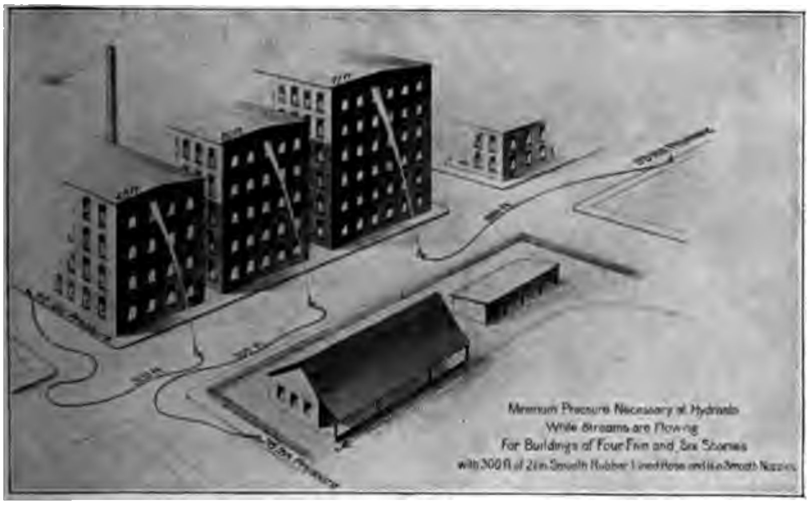

Minimum Pressure Necessary at Hydrants
While Streams are Flowing
For Buildings of Four Five and Six Stories

Fig. 267. Graphical Representation of Hydrant Pressures Necessary for Four, Five, and Six Stories Using Three Hundred Feet of Hose*

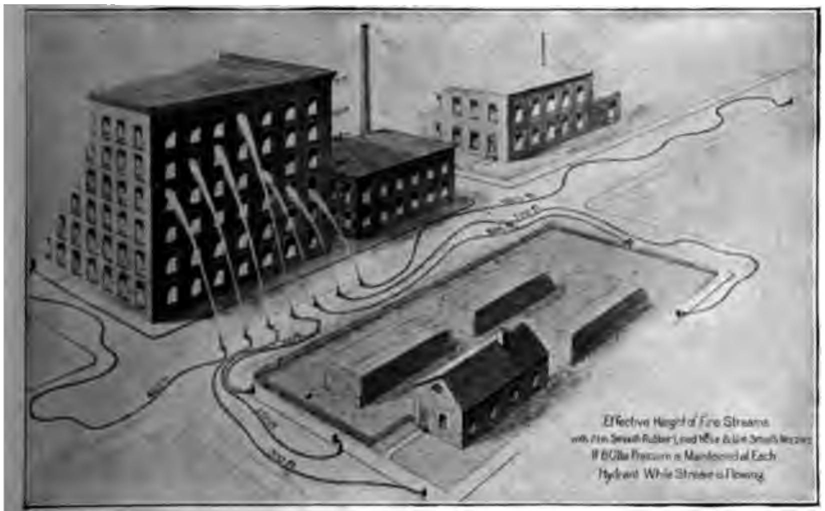

Effective Height of Fire Streams
Hydrant While Stream is Flowing

Fig. 268. Graphical Representation of Effective Heights of Fire Streams for 60 Pounds Hydrant Pressure*

**Courtesy New England Water Works Association* reserve to increase these quantities from fifty to one hundred per cent for conflagration use.

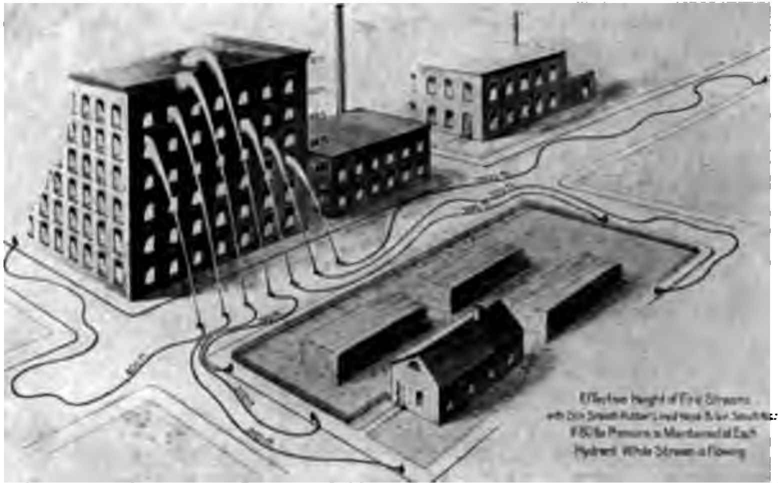

Effective Height of Fire Streams
with 2½ in Smooth Rubber Lined Hose & 1 in Smooth Nozzle
If 80 lb Pressure is Maintained at Each
Hydrant While Stream is Flowing

Fig. 269. Graphical Representation of Effective Heights of Fire Streams for 80 Pounds Hydrant Pressure*

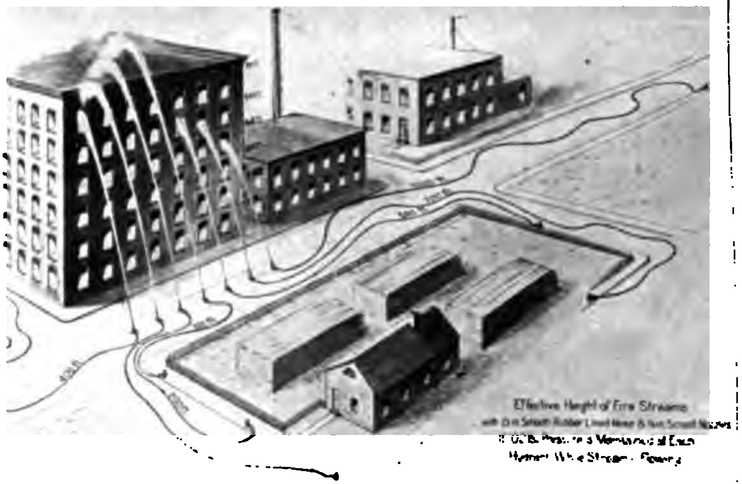

Effective Height of Fire Streams
with 2½ in Smooth Rubber Lined Hose & 1 in Smooth Nozzle
If 100 lb Pressure is Maintained at Each
Hydrant While Stream is Flowing

Fig. 270. Graphical Representation of Effective Heights of Fire Streams for 100 Pounds Hydrant Pressure*

* Courtesy New England Water Works Association

TABLE XX

Required Hydrant Pressures (Pounds) for 75-Pound Nozzle Pressure

Hose Diameter		2½ in.		3 in.		3½ in.	
Hose Lines		Single	Siamesed	Single	Siamesed	Single	Siamesed
Smooth Bore Nozzle		1⅛ in.	2 in.	1⅛ in.	2 in.	1¼ in.	2 in.
Length of hose line	100′	121	139	92	101	84.5	88
Length of hose line	150′	139	170	99.5	113	87.5	93.5
Length of hose line	200′	158	201	107	125	91	99
Length of hose line	250′	176.5	232	114.5	137	94.5	104.5
Length of hose line	300′	195	263	122	149	98	100
Length of hose line	400′	232	325	137	173	105	121

Note. From data derived from experiments by John R. Freeman (Transactions American Society of Civil Engineers, November, 1899).

The loss of pressure in the 3-inch and 3½-inch hose probably represents unusually good conditions, and in practice may somewhat exceed the above named figures. Not included in these figures are losses not exceeding 5 pounds incurred in a siamese connection, such as shown in Fig. 271, which is of the type used as the base of a standpipe of a high building.

The pressure that would give the best service in delivering this water depends upon the height of the buildings to be protected; upon the manner in which the water is to be distributed, that is whether through hose streams, automatic sprinklers, standpipes, roof hydrants, etc.; and upon the spacing of the hydrants, or in other words the length of hose necessary.

Table XX shows the hydrant pressures necessary to maintain a nozzle pressure of 75 pounds through various lengths of hose lines. Fig. 267 shows graphically the minimum hydrant pressure for a fixed hose length of 300 feet to adequately protect buildings of various heights, and Figs. 268, 269, and 270 show the possible heights of streams for various hose lengths for hydrant pressures of 60, 80, and 100 pounds, respectively.

TABLE XXI

Hydrant Pressures Required for Good Service in Sprinklers and Standpipes 100 Feet from Street Level

Inside hose streams, 1¼-inch nozzle, 400 feet, 2½-inch good hose, 25 pounds nozzle pressure..............	75 pounds

Inside standpipe streams (two in use) through two 400 feet siamesed lines, 3-inch hose, 100 feet 6-inch vertical pipe, 100 feet 2½-inch hose, 25 pounds nozzle pressure 1¼-inch nozzle	100 pounds
Automatic sprinkler system, two 400 feet lines, 3-inch hose, 100 feet vertical 6-inch pipe, 200 feet horizontal 6-inch pipe, 25 pounds maintained flowing 1,000 gallons per minute	160 pounds
Ground hose streams, 75 pounds nozzle pressure, 2-inch nozzle, two 400 feet siamesed 3-inch hose lines.	175 pounds
1¼-inch nozzle 75 pounds nozzle pressure, 400 feet 3-inch hose	140 pounds
Standpipe stream, 2-inch diameter universal nozzle attached to top of 6-inch standpipe 100 feet above ground, 75 pounds nozzle pressure maintained, two 400 feet siamesed 3-inch hose lines.	225 pounds
Two streams attached to roof hydrant on 6-inch vertical pipe 100 feet above ground, 1¼-inch nozzle, 2½-inch hose, each line 100 feet, 75 pounds maintained at nozzles, the standpipe fed through two 400 feet siamesed 3-inch hose lines.	225 pounds

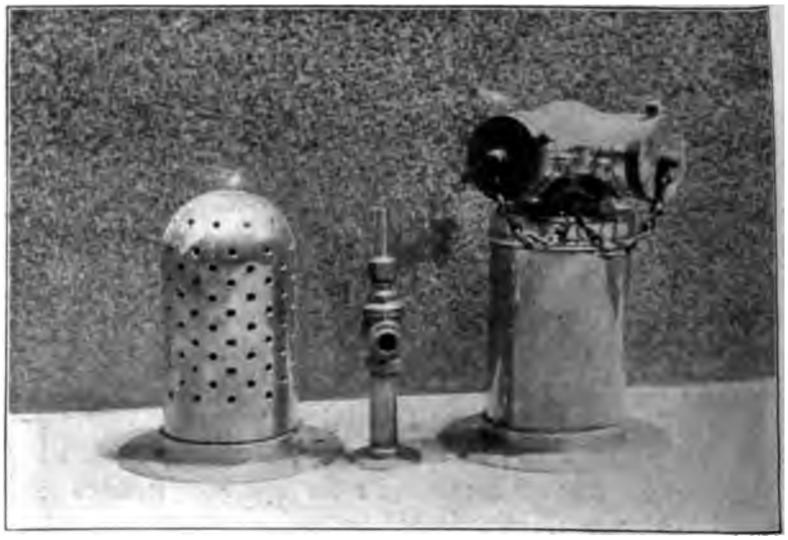


Fig. 271 Siamese Connection to Standpipe of a High Building

For fire streams from the ground, this nozzle pressure is sufficient whatever the height of the buildings, as considering the angle from which the water must be thrown the streams from the ground are of little value above the fourth or fifth story.

To give good service through automatic sprinklers, roof hydrants, tandpipes, etc., 100 feet above the ground, a high pressure service

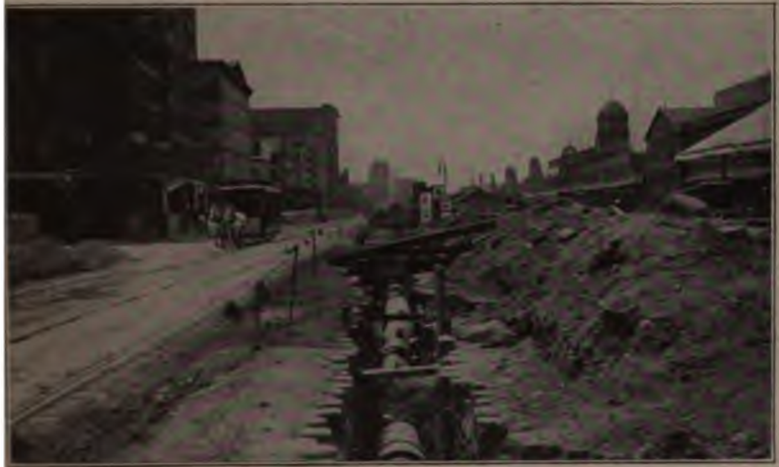


Fig. 272 High Pressure Pipes in New York City

hould be able to discharge a satisfactory amount of water at the ydrant pressures given in Table XXI.

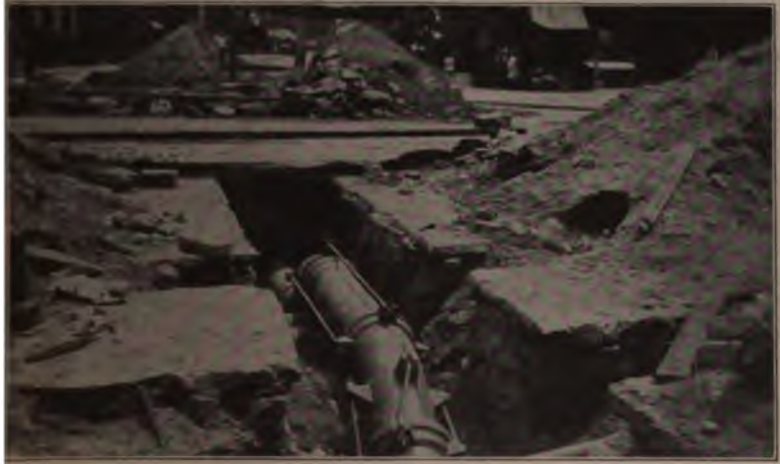


Fig. 273. High Pressure Pipes Showing Lugs and Stay Rods for Reinforcing Pipes

Piping Systems. *Pipe.* Extra heavy cast-iron pipe answer- g to requirements of the American Water Works Association, as shown in Table XXII, should be used for the high pressure piping system. Lugs are often cast on these pipes so that after the pipe sections are in place, iron rods may be secured by these lugs and the system thus reinforced, Figs. 272 and 273. All mains should be sufficiently large to deliver the maximum amount of water required without excessive friction loss. These mains should be gridironed and at least at every street intersection, there should be gate valves, so that if any section is injured by closing valves at either end, this injured section may be cut out without affecting the rest of the system.

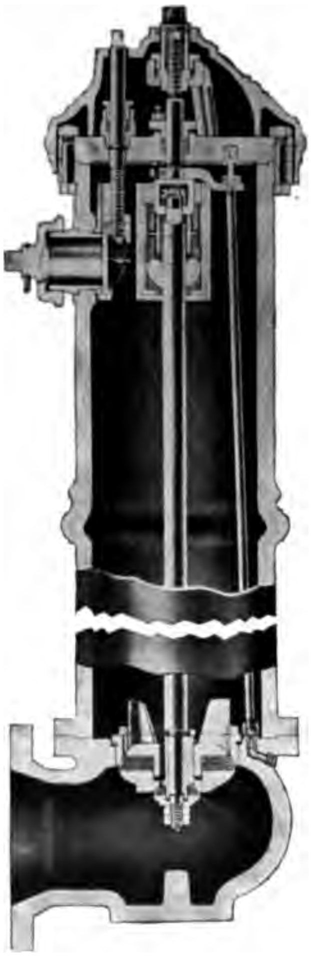


Fig. 274. High Pressure Hydrant. Valve Closed

Courtesy A. P. Smith Manufacturing Company, East Orange, New Jersey

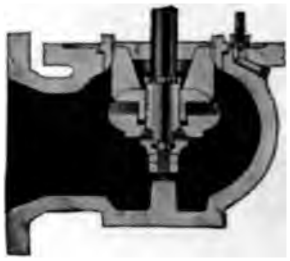


Fig. 275. Detail of High Pressure Hydrant Valve When Open

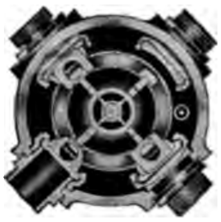


Fig. 276. Plan Section at Top of Hydrant

Valves. In connection with the N York High Pressure System, experimen are now being made with a system which a break in a main may be detected, exactly located, and t valves either side of it closed from the pumping station. A break a main suddenly decreases the pressure and this sudden drop i

TABLE XXII

Standard Thickness and Weights of Cast-Iron Pipe for Fire Lines and Other High Pressure Service

Classes E, F, G, H

Prescribed by American Water Works Association

Nominal Inside Diameter Inches	CLASS E 500-Feet Head 217 Pounds Pressure			CLASS F 600-Feet Head 260 Pounds Pressure			CLASS G 700-Feet Head 304 Pounds Pressure			CLASS H 800-Feet Head 347 Pounds Pressure			Nominal Inside Diameter Inches
	Thickness Inches	Weight per		Thickness Inches	Weight per		Thickness Inches	Weight per		Thickness Inches	Weight per		
		Foot	Length		Foot	Length		Foot	Length		Foot	Length	
6	.58	41.7	500	.61	43.3	520	.65	47.1	565	.69	49.6	595	6
8	.66	61.7	740	.71	65.7	790	.75	70.8	850	.80	75.0	900	8
10	.74	86.3	1035	.80	92.1	1105	.86	100.9	1210	.92	106.7	1280	10
12	.82	113.8	1365	.89	122.1	1465	.97	135.4	1625	1.04	143.8	1725	12
14	.90	145.0	1740	.99	157.5	1890	1.07	174.2	2090	1.16	186.7	2240	14
16	.98	179.6	2155	1.08	195.4	2345	1.18	219.2	2620	1.27	232.5	2790	16
18	1.07	220.4	2645	1.17	238.4	2860	1.28	267.1	3205	1.39	286.7	3440	18
20	1.15	263.0	3155	1.27	286.3	3435	1.39	320.8	3850	1.51	344.6	4135	20
24	1.31	359.6	4315	1.45	392.9	4715	....	.....	.....	....	.....	....	24
30	1.55	521.7	6260	1.73	585.4	7025	....	.....	.....	....	.....	....	30
36	1.80	725.0	8700	2.02	820.0	9840	....	.....	.....	....	.....	....	36

NOTE. The above weights are per length to lay 12 feet, including standard sockets; proportionate allowance to be made for any variation.

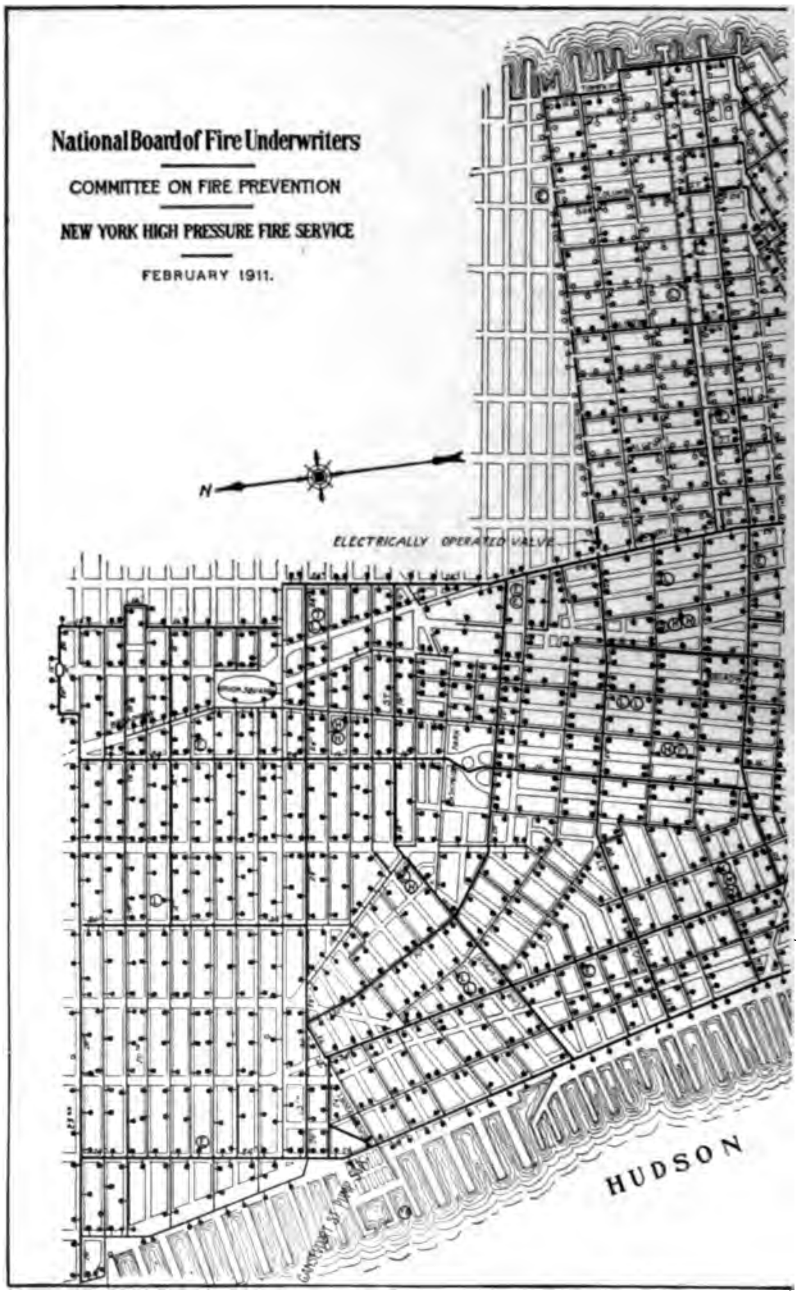
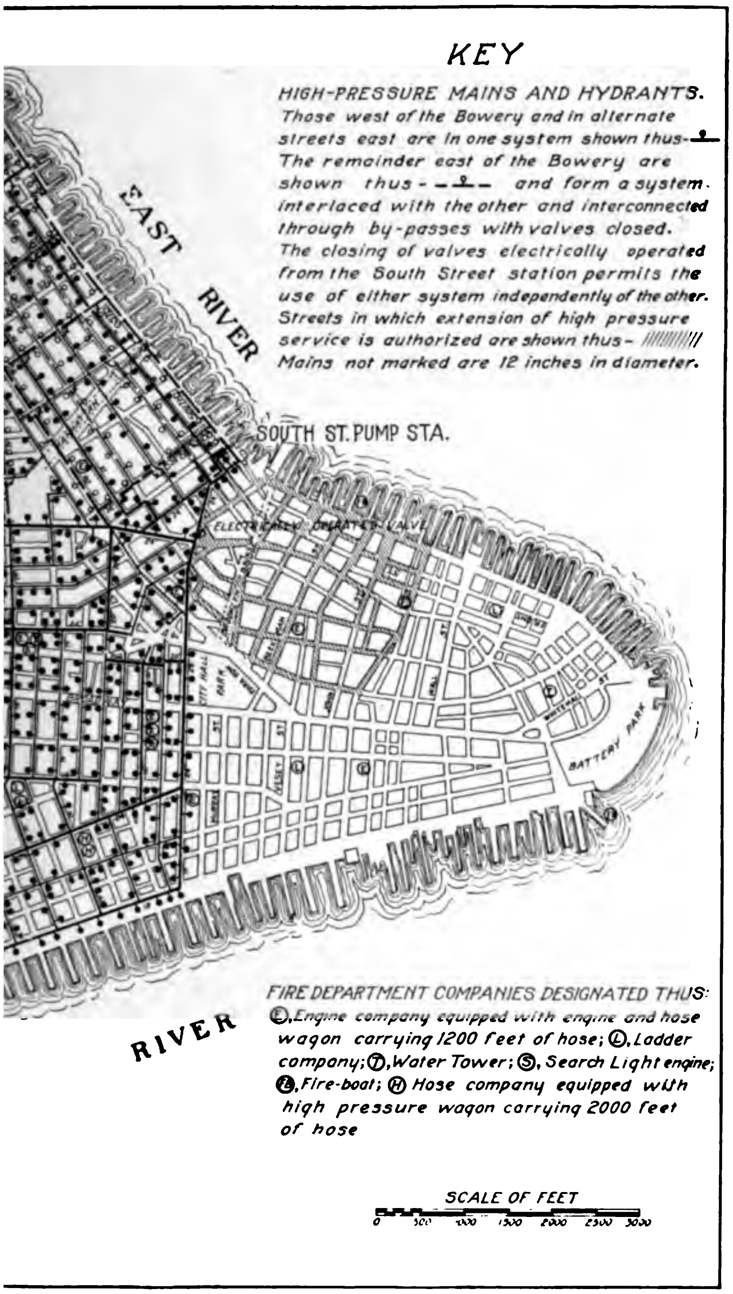

National Board of Fire Underwriters
COMMITTEE ON FIRE PREVENTION
NEW YORK HIGH PRESSURE FIRE SERVICE
FEBRUARY 1911.
N
ELECTRICALLY OPERATED VALVE
HUDSON

Fig. 277. Diagram Map of New York City Showing


KEY
HIGH-PRESSURE MAINS AND HYDRANTS.
Those west of the Bowery and in alternate streets east are in one system shown thus-
The remainder east of the Bowery are shown thus - and form a system interlaced with the other and interconnected through by-passes with valves closed.
The closing of valves electrically operated from the South Street station permits the use of either system independently of the other.
Streets in which extension of high pressure service is authorized are shown thus -
Mains not marked are 12 inches in diameter.
EAST RIVER
SOUTH ST. PUMP STA.
CITY HALL PARK
BATTERY PARK
RIVER
FIRE DEPARTMENT COMPANIES DESIGNATED THUS:
Ⓔ, Engine company equipped with engine and hose wagon carrying 1200 feet of hose; Ⓛ, Ladder company; Ⓣ, Water Tower; Ⓢ, Search Light engine; Ⓕ, Fire-boat; Ⓗ Hose company equipped with high pressure wagon carrying 2000 feet of hose
SCALE OF FEET
0
500
1000
1500
2000
2500
3000

f High Pressure System Installed and Proposed pressure actuates an electric device which starts one of a series of lights in the power station. The number of the light indicates the position of the break. By other electrical devices the proper valves may be closed.

Hydrants. The hydrants for high pressure service, sections of which are shown in Figs. 274, 275, and 276, should be larger, leave more outlets, and be more closely spaced than those on ordinary supply systems. Those in New York City were selected after most thorough tests had been made of several kinds of hydrants, the ones chosen being twice tested for tightness under a hydrostatic pressure of 300 to 600 pounds.

The main valve of the hydrant is six inches in diameter and opens downward against the pressure of the water. To make this easily possible, the first few turns of the wrench opens a little pilot valve admitting water to the hydrant barrel and thus equalizing the pressure on both sides of the main valve, which can then be readily screwed down. Opening this valve closes the drip, which is automatically opened when the hydrant is closed. There are four hose outlets to each hydrant—one 4½ inches and three 3 inches on some; and four 3-inch outlets on others. The controlling valves on these are also arranged so that after a few turns the pressure on either side is balanced and the valves easily opened. It is necessary, however, to open the main valve first. If the hose valves are first opened, the water escapes from the hydrant barrel and does not build up the pressure on the main valve.

The map shown in Fig. 277 gives the arrangement of the mains and spacing of the hydrants of the New York High Pressure System.

High Pressure Systems in Various Cities. High pressure systems may be divided into three classes according to the means by which the high pressure is obtained; viz, *gravity, fire boat pressure,* and *pressure from a permanently located pumping station.* According to the means at hand, different cities have designed and built these systems in different ways as shown by the few instances given as follows: Newark, N. J., and Washington, D. C., have gravity systems; Milwaukee, Detroit, Buffalo, Cleveland, and Boston have fire boat systems; Philadelphia and Coney Island have permanently located gas driven pumping systems; and New York has permanently located motor driven pumping systems.

Gravity Systems. In Newark, N. J., the original supply for all purposes was distributed by gravity, but with the increasing demands of a growing city the pressures as well as the supply became so small that a separate gravity high pressure fire system, giving pressures from 100 to 130 pounds, was installed.

Fire Boat Pressure. About 1888, Cleveland and Milwaukee installed high pressure piping and hydrant systems in their business districts so arranged that fire boats could be attached to connections provided at several wharves. Fire boats are expensive to construct and to maintain and these original systems were designed to extend the field of usefulness of the powerful pumps of these boats from the water front to the valuable inland district. Since 1888, other cities having water fronts such as Buffalo, Boston, and Detroit have installed fire boat high pressure systems. In the Boston system salt water is used. Before constructing this system, experiments were made to determine the action of salt water upon the various parts that would be required. It was found necessary to insulate from each other all metals of different electrical potentials

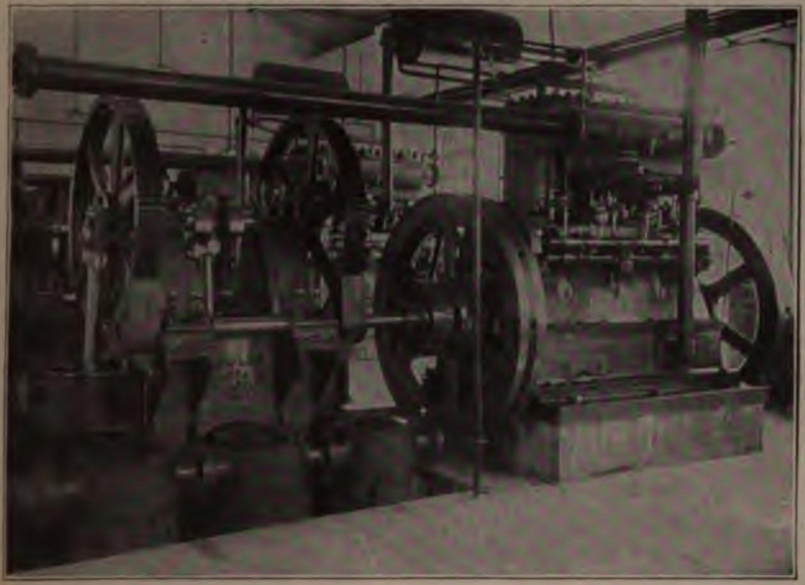


Fig. 278. Gas Driven Pump for High Pressure Service at Coney Island

in order to prevent galvanic action. Although as valuable as fresh water for extinguishing fires, salt water does more damage both to the buildings and their contents and thus is not so desirable as fresh.

In some of these systems, the pipes slope toward the fire boat connections so that in winter they may be drained each time after they are used, though in summer the system may be kept primed, that is, pipes filled with water, and ready for use. It will readily be seen that such systems require complex and numerous valves to allow the air to escape when the water enters; to permit of thorough draining; to prevent back flow when more than one boat is operating; and to allow for water hammer. Considering the conditions under which these systems operate, the nature of the water used in most cases, the long periods of disuse, which afford every opportunity for the valves to stick and for ice and sediment to be present, and that a certain amount of time is required to summon the fire boats and attach them, the auxiliary supply systems of these cities have done excellent service.

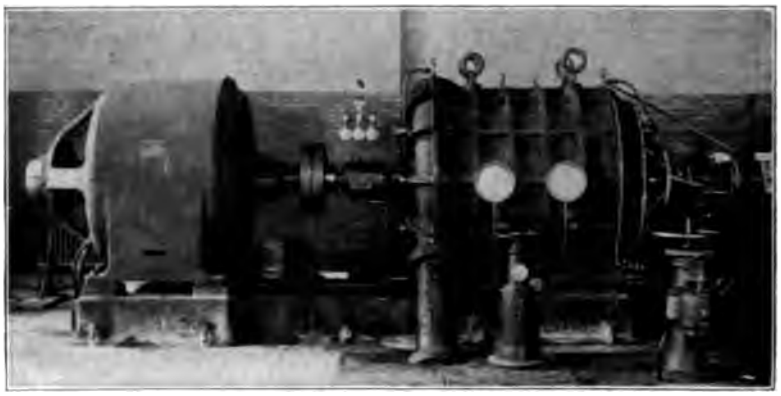


Fig. 279. High Pressure, Turbine-Driven Centrifugal Pump Used in Power Station, New York City

Pressure from Pumping Stations. Philadelphia was the first city to have a more elaborate system. The supply system, if it was to be called upon for both domestic and fire purposes, had grown inadequate for the city, although it was large enough to meet all calls for domestic uses for some time to come. The solution was the installation in 1903 of an independent fire system supplied by permanently located gas driven pumps drawing from the Delaware

River. This system can deliver 9,100 gallons per minute under a maximum pressure of 300 pounds. Provision was also made to attach fire boats to this system in an emergency.

Although on a much smaller scale than the one just mentioned, the high pressure service at Coney Island is also obtained from permanently located gas driven pumps, Fig. 278. This power could be obtained with less difficulty and expense than any other.

In 1906 a system much larger than any ever constructed previously was opened in Brooklyn, New York. (See Fig. 187, "Fire Insurance Inspection," Part IV.) In 1908 a similar system was opened in the Borough of Manhattan, New York City, Fig. 279; in both systems the motor driven multi-stage centrifugal pump having been used. The rated capacities of these systems are respectively 32,000 and 30,000 gallons per minute under 300 pounds pressure at the pumps, though provision is made to increase this amount by attaching fire boats and also pumping salt water into the system.

The initial supply in the New York system comes from the Croton aqueduct; but if necessary the pumps may draw from the salt water, and besides these supplies, fire boat connections are provided as already mentioned.

Alarm Systems. Various methods of sending alarms and signals between the officer in charge of a fire and the power station or boat are employed. At the first alarm of fire in a high pressure zone of a fire boat system, the boats are usually required to attach to the nearest wharf connection and in some cases to fill the system and await further orders.

In Detroit originally a single wire was laid in a pipe in the same trench with the high pressure mains, and signals in code form were sent along this wire by means of push buttons located at each hydrant; thus, 1 bell start pump; 2 bells stop pump; 3 bells 20 pounds less pressure; 4 bells 20 pounds more pressure; and 6 bells pick up. Their present system is as follows: A common battery telephone and battery is on the boat, on which is also provided a flexible, double-conductor cord kept on a suitable reel. The duplex wire along the line is multipled up to each hydrant to a telephone jack—a similar jack or contact socket being provided at the river end. A portable telephone set is plugged in at any hydrant, forming a common battery circuit.

In some cities, street telephone boxes are placed at such frequent intervals that a fire, wherever located, may be visible from one at least, and from these boxes the power station may receive orders as to the pressure required. These signaling systems, however, are not wholly satisfactory. Telephone communication is necessarily slow and it being especially difficult on stormy days and on noisy streets, mistakes in understanding the orders may frequently occur. As there is no permanent or stamped record made of telephone signals the blame for any misunderstanding can not be fixed. Considering all these weak points, it is probable that a telegraphic signaling system will soon be designed to supersede the present telephone system.

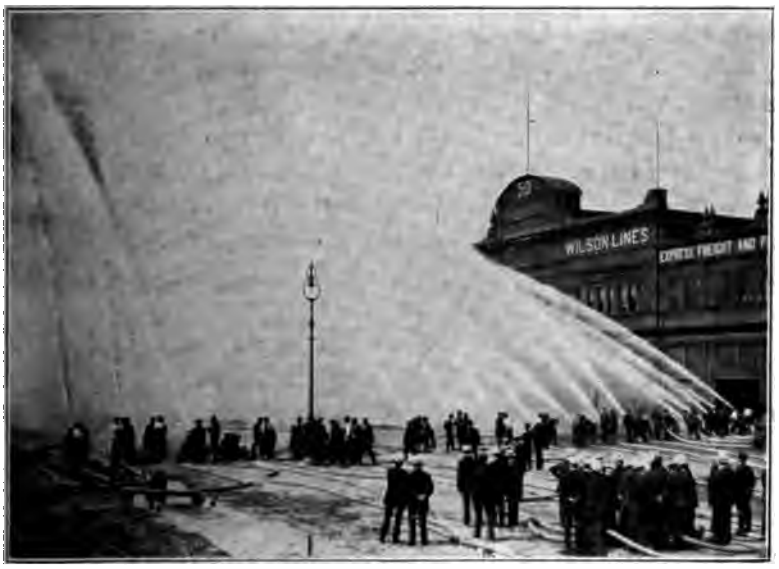


Fig. 281. High Pressure Service in Action. Contrast with Fig. 280

Uses. The cities provided with high pressure systems use them differently. In some, as has already been mentioned, the system is primed at the first alarm of fire and the department awaits further orders. When the pumping station is permanently located, some fire chiefs order that it supply certain pressures at a first alarm fire, so that as soon as the light hose trucks are at hand, water and pressure may be available; while other cities use fire engines for first alarm fires and high pressure for more serious fires.

Some experience seems to show that when high pressure systems are used the firemen have a tendency to stand off and drown out the fire instead of fighting it at close range, and in this way the water damage is excessive. In no case have the fire engines been taken from the districts protected by high pressure even though these systems are equivalent to a great many engines. For instance in New York, the pumping stations have a rated capacity of 30,000 gallons per minute. Fire engines are rated in capacity from 500 to 1400 gallons, so that theoretically it would require twenty-five of the largest type of engine to equal the high pressure system. However, under actual conditions these engines pump about 800 gallons per minute, and assuming that the high pressure does not work at maximum capacity, and making other allowances, it is approximately correct to reckon that it takes thirty engines to equal the working capacity of the high pressure system. From Figs. 280 and 281 comparisons can be made of the efficiency of hose streams from a first size fire engine and a first class high pressure system. In being able to do the work of so large a number of engines it overcomes the massing of so many engines about a fire.

Disadvantages. The pressure generally supplied by high pressure systems is such that the streams can not be handled safely by hand, while, by using fire engines, the pressure required in different hose streams could be easily regulated. It is often necessary for firemen to handle streams in dangerous places where they may need to back out quickly; or they may wish to get a hose up a ladder, a fire escape, or up the stairs; and any one of these conditions requires streams that may be easily and absolutely controlled. With a high pressure stream such control is difficult. Various high pressure handling devices have already been described and illustrated under the section on Fire Department Equipment.

Controlling Valve. When two or more fires occur simultaneously in a high pressure district it may happen that different pressures would be required at the different places; for instance, the company at a small fire may ask for and be working with a pressure of 125 pounds, while the officer in charge of a large fire sends an order for a 200 pound pressure. The increase of pressure at the pumps due to the second order would increase the pressure throughout the entire system and, of course, through the hose streams and other apparatus used by the first company without warning to the men at work, and such unexpected force might seriously endanger the men. To prevent these conditions and to permit of taking streams under different pressures from the same hydrant, a pressure regulating valve has been designed. This is a portable valve weighing about 25 pounds, designed to be attached to the hydrant outlets. A pressure gauge at the hose side is set at the desired pressure and no matter to what extent the system pressure may be raised, the valve will keep the hose pressure down to the figure at which the gauge is set. It also acts automatically to keep the hose pressure at the same point even when a controlling nozzle is suddenly shut.

Conclusions. Besides furnishing hose streams, the high pressure systems can be connected with the standpipe and roof hydrants, and with the inside and outside sprinkler equipments. Up to the present time, flexible connections only are made between the high pressure system and the private fire fighting devices; however, many authorities advocate the installation of permanent connections between these systems and automatic sprinkler equipments. The most expensive parts of a sprinkler system, either to install or maintain, are the pumps and the gravity or pressure tanks. It is believed that the use of sprinklers would become much more general if a satisfactory water supply could be obtained easily and inexpensively, as would be the case if those having jurisdiction would grant permission to make permanent connections to the high pressure systems.

The most serious objection to this being done is the possibility of the sprinklered risk burning and so injuring the large pipes between the street and the system in the building, that the high pressure pipes might be bled so seriously as to affect the efficiency elsewhere. It seems that such a condition might be prevented by the installation of proper valves for outside control.

In general the experience with high pressure systems has been so satisfactory that there have been material reductions in the local insurance rates following their installation. Table XXIII corrected to 1909, shows the High Pressure Systems of the United States and Canada.

TABLE XXIII

High Pressure Fire Service in the United States and Canada

System	Estimated Population	Date of Installation	Source of Pressure	Gallons Per Minute	Maximum Pressure, Lbs.	Lineal Feet of Mains	Sizes of Mains, Inches	Number of Hydrants	Total Cost of System	Number of Acres	Cost Per Acre	Connection with Building	Effect on Insurance Rates
Atlantic City	10,000	Proposed	1 Stat. Elec. Turb. Pumps	7,000	225	38,590	8-14	82	$187,272	306	$612	....	....
Baltimore..	575,000	Proposed	Pump. Sta.	.....	..	75,000	10-20	....	*307,990	360	.....	Standpipes on Buildings	....
Boston .	620,000	1898	Fire Boat	6,000	200	4,700	12	14	30,080	65	463	....	.
Brooklyn.	1,400,000	1906	2 Pump Sta. Elec. Turb. Pumps	32,000	300	......	8-20	....	1,384,500	1420	975	....	....
Buffalo.. .	420,000	1897	3 Fire Boats	....	300	12,756	12	....	....	....	.....	....	Reduction of $.30 per $1000
Chicago......	2,229,000	....	....	....	...	....	....	....	....	....	.....	....	....
Cleveland....	480,000	Constructing	2 Fire Boats to Have Pump. Sta.	10,000	300	32,524	8-20	96	*170,000	338	.....	May have Connection with Auto. Sprinklers	Reduction of $0.80 per $1000 Prop.
Coney Island	....	1905-6	1 Station Gas Triplex Pumps	3,600	150	....	8-16	....	90,000	147	612	....	Reduction of 25%
Detroit......	380,000	1893	2 Fire Boats	10,000	210	25,831	8-10	95	....	356	135	....	Probably has Prevented Increase
Fitchburg...	33,000	....	Gravity†	....	180	28,250	8-16	....	50,000	346	144	Boiler Feed, Elevators and Sprinklers	Prevented Increase
Hartford.. .	98,000	Proposed	1 Station	10,000	300	53,430	8-24	108	706,277	731.3	1089	No open Connection	....

* Exclusive of pumping station and equipment.

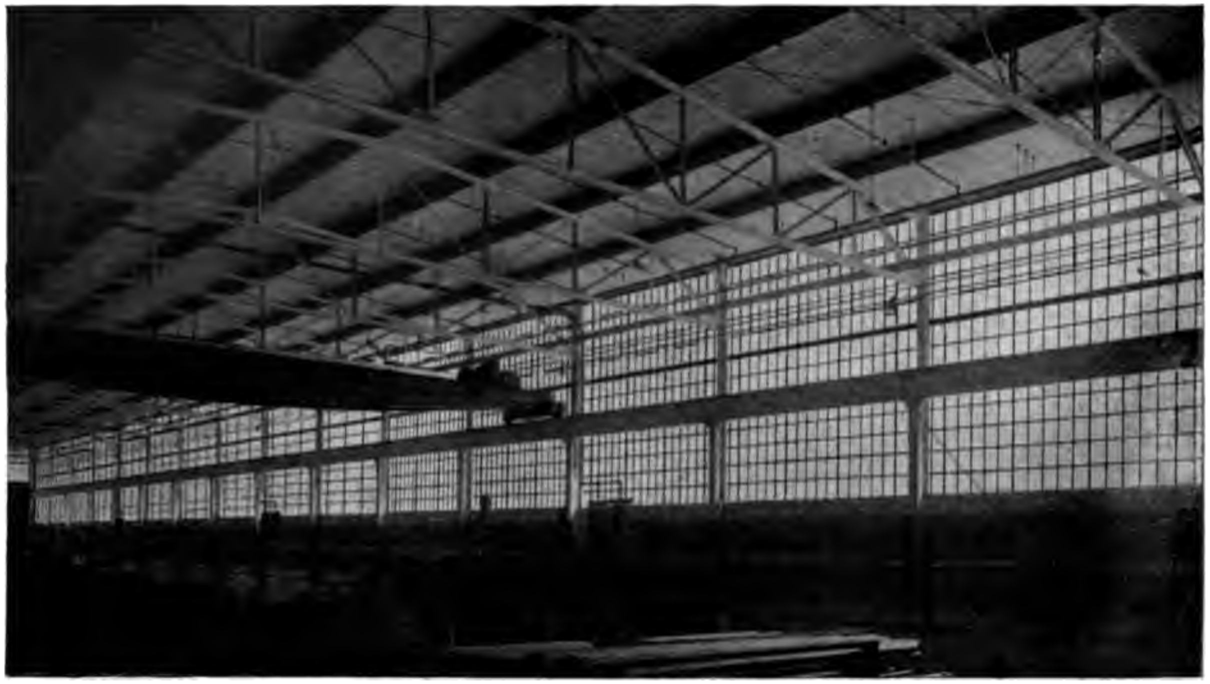
High Pressure Fire Service in the United States and Canada—Continued

System	Estimated Population	Date of Installation	Source of Pressure	Gallons Per Minute	Maximum Pressure, Lbs.	Lineal Feet of Mains	Sizes of Mains, Inches	Number of Hydrants	Total Cost of System	Number of Acres	Cost Per Acre	Connection with Building	Effect on Insurance Rates
Lawrence....	75,000	1906	Gravity†	....	134	10,200	10–12	39	....	120	.....	....	No change
Milwaukee...	340,000	1889	3 Fire Boats	15,000	250	45,717	6–12	183	....	630	.....	....	10% Reduction
Newark......	290,000	1905	Gravity	3,500	165	15,000	20–30	52	135,000	303	446	Some Connection	10% Reduction
New York.... (Manhattan)	2,100,000	1908	2 Stations Elec. Turb. Pumps	30,000	300	....	12–24	1200	3,950,400	1430	2763	Water Curtains Provided for	No change
Philadelphia .	1,500,000	1903	1 Station Gas Triplex Pumps	9,100	300	35,300	8–16	166	700,000	512	1367	None on or in Buildings	Penalty of 25% Removed‡
Providence...	200,000	1897	Gravity†	3,472	116	29,000	12–24	89	143,136	358	400	5 Automatic Sprinklers	No change
Rochester....	185,000	1874	2 Stations Elec. Turb. Pump, Steam Turb. Turb. Pump	9,000	140	102,960	4–20	....	....	.....	.....	Some Connection	Graded Reduction
Toronto......	215,000	Constructing	1 Station Elec. Turb. Pump	14,000	300	40,000	8–20	....	500,000	287	1742	Considering Connection	Uncertain
Winnipeg....	110,000	1908	1 Station Gas Producer Gas Eng. Trpl. Pumps	10,800	300	15,840	8–20	....	650,000	275	2364	Connection with Auto. Sprinkler	Uncertain
Worcester....	138,000	....	Gravity†	....	165	100,320	8–30	....	....	1380	.....	Elevators	No change

† System consists of extension of pipes from high service into district covered by low service

‡ Board of Fire Underwriters have voted to reduce rates to the amount of 10 cents per $1000 = a total of $40,000, if extensions costing $150,000 are made to the system.

Note. This table is taken from the report on the proposed high pressure fire system for Hartford, Conn.



INTERIOR OF FACTORY, GENERAL FIRE EXTINGUISHER COMPANY, WARREN, OHIO
Entire Side of Building Equipped with United Steel Sash Furnished by Trussed Concrete Steel Company, Detroit, Michigan

FIRE INSURANCE INSPECTION

PART VI

COMMON AND SPECIAL HAZARDS

INTRODUCTION

Common hazards, or common causes of fire, are those ordinary and universal conditions and operations that may cause fire, which are common to a greater or less extent in all classes and occupancies of property, irrespective of the special hazards of that particular class, due directly to the occupancy or work carried on therein.

The usual causes of fire may seem commonplace, but the predominance of the commonplace is an accepted fact. The hazard due to smoking or to the use of matches is as potent and prevalent in the finest factory of most intricate and specialized processes as in the most humble dwelling. Lightning is no respecter of persons or things but strikes with equal impartiality the great barn bursting with the grains of a bountiful harvest or an abandoned and weather-beaten grist mill of former days which has long since outlived its utility or beauty. While it is more interesting to study the processes and hazards of some novel but prominent industry, it is important and necessary that we should give thought to everyday occurrences; should examine the hazards of these common causes of fires in considerable detail; and should recognize the importance of such study. A large percentage of fires in dwellings and mercantile properties, etc., is due to common hazards. In factories, although the largest number of fires in some instances may be due to special hazards, the greatest proportion of large losses is almost invariably due to common hazards and exposure.

Special hazards are those special conditions and operations due directly to the processes of manufacture, characteristic work, or nature of occupancy of a specific class, which have the potential possibility of causing fire, irrespective of those hazards which are common to any and to all classes of occupancy.

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In general there is a clear-cut distinction between the common hazard and the special hazard. Occasionally, however, there may be an overlapping that might at first seem confusing, but which should be perfectly clear when each case is considered by applying the definition of common and special hazard. Consider, for example: A cotton mill is equipped throughout with electric motors which are supplied by a current generated in a small detached boiler and power house, an adjunct to the plant. It is clear that any hazard in connection with the generator in that power house is a hazard of power, a hazard common to all classes of plants. On the other hand, remove the cotton mill and picture this small power plant as transformed into a large central electric power station. This station then becomes a specialized plant—a manufactory, in fact, of electric current for general distribution. Then, according to the definition of the difference between special and common hazards, the hazards involved in the electric generating system are special hazards and should be so considered.

There is a natural tendency among those who have had any field experience, and perhaps especially among the trained inspectors, to become at first most interested in and concerned by the occupational or special hazard. This is the most impressive source of hazard and frequently receives the greatest thought, to the neglect of the common hazards. In the nature of things, the special hazard can often receive more specific treatment than any other with more spectacular results. A notable example was the segregation of the picker hazard in the cotton mill, which at one stroke reduced the special hazard of that class from one of the severest known at the time to one of negligible consequence in underwriting. The same tendency of treatment is exhibited in the detached boiler house, but still steam must be introduced into the mill. Power must be distributed, and no matter where the source is, the common hazard of friction is ever present wherever a wheel turns. Light must be carried to every part of the plant and the system possesses as much hazard in one location as in another, and perforce the hazard is equal throughout.

A correct knowledge of the causes of fire is a very necessary preliminary to the taking of effective measures for their cessation or prevention. These causes, at first few and simple, have now becom many and complex because of the multiplication of inventions an resources and the introduction of new products and systems into commerce. Only a comparatively few years ago there were no more than two forms of light or power in use, while now there are a half dozen or more forms of each in common use. The development of the pyroxylin plastic (commonly called *celluloid*) industry has introduced a chain of allied industries and important special hazards incident thereto; such as the manufacture of moving picture films, artificial leather products, lacquers, etc.

The economic evolution which is constantly taking place, occasionally produces a condition of less hazard; but in general the disappearance of some well-known hazard is superseded by the introduction of several new ones—conditions which must be met at once. The well-informed insurance man, be he an underwriter or engineer, agent or clerk, should therefore endeavor to keep informed on the nature of these systems, processes, and advances, their operation and hazards, so that he can at all times be ready to give service to his clients with satisfaction to himself.

Note: By reference to "Rules and Requirements" is meant the rules and requirements of the National Board of Fire Underwriters as recommended by the National Fire Protection Association, which pertain to the particular subject under discussion. These are issued in small pamphlet form and are freely distributed without cost. Those that pertain to the particular subject under discussion should be carefully studied. By reference to the "Lists of Appliances" is meant the "List of Gas, Oil, and Chemical Appliances" and "List of Fire Appliances," which are issued separately semi-annually by the National Board at the recommendation of the Underwriters' Laboratories, Inc. Approved or listed devices refer to the devices which appear on these lists. The Underwriters' Laboratories' approval or label is accepted as evidence of proper construction of the appliance at the factory.

COMMON FIRE HAZARDS

LIGHTING

The development and utilization of lighting systems from the most primitive forms of ancient times to the most complex systems of the present day have been a prolific source of fires. Although the improvements which have been made in such systems, as electric lighting, have greatly reduced the variety of causes, a certain percentage of all fires will probably continue to be attributable to lighting systems.

Candles. *Manufacture.* The tallow dip is mentioned by a Roman writer of the second century A.D., and until modern times has been largely an article of domestic manufacture. Waxlights were probably of earlier invention. Two distinct guilds of candlemakers, the "Waxchandlers" and the "Tallowchandlers," conducted the candle industry in England during the Middle Ages. In 1484 a company was formed in London to manufacture wax candles. Spermaceti came into use as a substitute for tallow about 1750, while paraffin was not introduced for this purpose until about 1854. A mixture or composition of paraffin and stearine is now very generally used for candle manufacture, the proportion of stearine being the greater for candles which are intended to be burned in hot climates.

Consumption. In old fire records of London during a period of thirty-three years, and after the introduction of gas, eleven per cent of the fires were due to candles and seven per cent were due to gas. Few probably in this present day have considered to what extent candles are used, or have realized that candles today have a share in the cause of fires. As a matter of fact, the manufacture and consumption of this time-honored commodity are said to be increasing annually from ten to sixteen per cent.

Uses. Tons of candles amounting to millions of lights, are burned every year on the altars of Episcopal, German Lutheran, and Roman Catholic churches. The custom of keeping fire of some kind before consecrated objects has been associated with religious worship by peoples of all races; it exists in Chinese joss-house as well as in Christian cathedral; and it was ancient even when the Vestal Virgins guarded the sacred fire of Rome. The use of candles at altars and in connection with certain religious rites and ceremonies, constitutes a fire hazard which, although small because of careful and conscientious attendance, is, nevertheless, very real. The use of candles for the decoration of Christmas trees has been a prolific source of fire and horror. Plumbers and mechanics use a large number of candles and frequently go away leaving them burning on the floor or in some other favorable place for setting a fire. The use of candles for exploring dark places, looking for gas leaks and entering cellars or attics, etc., is fraught with those hazards common to the use of an open flame which may come in contact with inflammable material, or ignite volatile or explosive vapors.

Precautions. Candles should be eliminated where possible. The use of lights in the public worship of the Catholic Church is governed by detailed ecclesiastical regulations which, in general, prescribe the minimum quantity to be used on various occasions, and combustible candles must be used to a certain extent. However, it is perfectly feasible to substitute electric lights for many extra candles, for it is customary to use many more candles than are demanded by the minimum requirement. Where candles must be used, precaution should be taken to prevent upsetting by placing them in permanently fixed or safely balanced holders, free from possible contact with light, inflammable material.

The use of candles for the decoration of Christmas trees should be absolutely prohibited under all conditions. The use of candles for the other purposes enumerated above should be discouraged, and that of electric hand torches, where portable lights are necessary, strongly advocated. These are very satisfactory for momentary lights.

Torches. Open torches, burning kerosene or other inflammable liquids, are sometimes used by mechanics and millwrights in making repairs around the dark places to be found in a factory, such as shaft holes, engine pits, beltways, etc. These locations are likely to have an accumulation of oil, grease, and lint, and thus fires are readily started and spread with amazing rapidity. Most fires originating around belts have been from this cause. Here the fire quickly travels beyond its origin and thereby whole mills have frequently been destroyed. As a general rule, these torches should be prohibited; but where used, constant care must be taken to keep the open flame from coming in contact with inflammable material.

Gas Lighting. *Development.* The first authentic record of an inflammable gas from coal, which is usually spoken of as illuminating gas, retort gas, or city gas, dates from 1739. In 1792 William Murdoch conceived the idea of applying this gas to economical purposes; and in 1798 he fitted up the engine works of Messrs. Boulton and Watts, in Birmingham, with the appliances for illumination. In 1807 gas lights first appeared in the streets of London, and the first company was formed in 1812. The so-called water-gas was introduced through the experiments of Lowe and Du Motary in the United States during 1873. At present, the amount of water-gas sold for public use is in the neighborhood of 75 per cent of the entire quantity of gas sold. The advent of electricity for lighting purposes did not check the progress of gas. On the contrary, as has been the history where improved methods of lighting have developed, both kinds of lighting profited by the increased efficiency. Since the introduction of the incandescent mantle, notwithstanding the fact that the resultant yield of illumination per cubic foot consumed was practically quadrupled, the output of gas has been continually on the increase, and the gas sales in large cities have grown almost twice as fast as the population.

Properties of Gas. City gas, as we know it today, is somewhat different from the gas which results from the ordinary destructive distillation of coal; for water is introduced into the process and passed through the hot bed of coal, the water being broken up into its constituent gases which enter into the general composition. Naphtha is also used to a certain extent. Water-gas has less smell than straight coal gas. Consequently a leak is less easily discovered, and serious explosions have occurred due to this fact. Average city gas is much lighter than air. Coal gas has an explosive range from eight (8) to twenty-three (23) parts of gas with air, and water-gas a range of from nine (9) to fifty-five (55).

Methods of Use. Gas is used in open flame jets with either fixed or swinging brackets; in mantle lamps with upright or inverted burners, and with permanent fixtures or portable table lamps; and in gas arc lamps. Gas is supplied from a central gas plant through street mains. Private connections, usually three-fourths-inch pipe with or without shut-off valves, supply the system. Registering meters are placed in the connection and frequently are located in basements. Inside shut-off valves are located near meters. Gas is piped to all permanent fixtures in the building. Portable lamps are generally supplied by flexible rubber tubing.

Gas Lighting Hazards. The chief hazard of gas lighting systems comes either from the gas jets themselves or from the prevalent use of matches for lighting the gas. The latter feature was at one time considerably reduced in a measure by the use of electric igniters. The use of these igniters, however, is limited by the Underwriters' requirements to those fixtures that are piped for gas alone. The increasing use of combination fixtures for gas and electricity has reduced the use of electric gas igniters very materially. Jets being moved in contact with inflammable material, or curtains, etc., being blown across the open jets, cause many fires; also burners located too near ceilings. Hot lava tips may be blown out of the gas burner and landed on some inflammable material. It is said that the so-called genuine lava tips are now made from talc spar and cheaper ones from soapstone. Mantle burners are rapidly superseding the jets. Leaky pipes and fixtures are dangerous. Flexible rubber tubing is hazardous. This tubing was formerly specially made with great care and sold at forty cents per foot. The best tubing in the market for this purpose now sells for about twelve cents per foot and is an inferior and even dangerous subterfuge. In gas arc lamps, glowing particles of the mantles are liable to fall through the bottom, and occasionally gas arcs burn in two and allow the lower part of lamp to fall on inflammable material. Rubbish and inflammable material piled around or in close proximity to gas meters; soldered joints easily melted by small fire and gas ignited; lack of outside shut-off gates on mains are all serious hazards. There is also the possibility of striking or blowing out the gas flame, or of its being extinguished by fluctuations in gas pressure. This produces a condition, due to the escaping gas mixing with the air, where an explosion is possible.

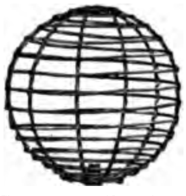

Fig. 282. Wire Bonnet for Gas Jets

Protection. Stationary gas jets are preferable. Movable jets should have suitable stops provided. Suitable wire guards should be attached around jet in either case. An example of such is shown in Fig. 282. Jets should in no case be less than eighteen inches below ceilings or under any inflammable material; and if less than thirty-six inches, they should be provided with a heat deflector suspended at least four inches below the ceiling or material exposed. Piping and fixtures should always be installed by reputable experts. The use of flexible or rubber tubing should be discouraged. Where flexible connections are necessary, place the valve where the tube joins the gas pipe—not at the burner. Arrange shields under gas arcs. Gas meters should be in a safe part of the building where least liable to accident and where they may have free circulation of air. Inflammable material should not be stored in close proximity to meters. Arrange guards, if need be, to keep storage material away. Require outside shut-off gates in all private connections.

Kerosene Oil Systems. *Lamps.* Lamps were used in the early ages in Egypt, Greece, and Rome. Lamps with horn sides are said to have been invented by Alfred the Great who died in 901. London streets were lighted with oil lamps in 1781. In 1784 a Frenchman invented a lamp which would neither smoke nor smell. About 1803, Carcel invented a lamp founded on the principle of Argand, in which by means of a hollow wick and a glass chimney a strong and clear light was produced by placing the flame between two currents of air. However, lamps such as we know them now were developed since the practical introduction of petroleum and kerosene. The real development of this industry dates from the discovery by Mr. Drake of a productive oil well near Titusville, Pennsylvania, in 1859.

Use. Very few manufacturing properties are today lighted by kerosene oil lights, but a vast number of dwelling and mercantile properties are illuminated by this means. Kerosene oil lighting is considered more hazardous than gas or electricity and is not approved (except the approved watchman's lantern) in buildings of standard mill construction.

Hazards. Hazards are mostly those of care and use. Cleanliness is the first law of safety in illumination by coal oil. There is but little danger of the modern kerosene lamp exploding if it is kept clean. The little flat tube alongside the wick-tube is an open passage for the constant escape of vapors from the oil, which, if confined, would cause trouble. This vapor is consumed in the flame of the lamp without noise or danger. It is when this tube and the wick-tube become dirty or choked with soot or wick-carbon that the danger of explosion is present. A good white light may be insured by removing the char from the wick daily, and never burning the wick more than half its length. Dirty metal, which retains the heat to a far greater degree than a nicely polished lamp, causes the vapor to rise from the oil, and thus an explosion is likely to occur.

Only metal lamps should be used, and the central draft type is not desirable. Round burners are safest, and the bowls should be so large in proportion to the burner that the ordinary burning period will not consume more than two-thirds of the oil. Most of the fires and deaths from lamps are due to the accidental upsetting of the lamp, frequently done by children. No one having children in the house should permit the use of any lamp with a small base. Some lamps are so made and weighted that they right themselves if tipped over. Broad, heavy-based lamps kept permanently in one place are safest. Where lamps are to be permanently located, as in factories, stores, etc., they should be supported by suitable metal hangers and proper heat-guards provided to protect the hanger and the material overhead. The lamps should be taken to some suitable place outside of the main premises for filling and the supply of kerosene kept at that point. Lamps should always be filled in daytime and never when lighted. Paper and cloth shades should never be used on lamps. Only high test oil should be used, but this is well governed by law and inspection in most states.

Note: The specifications of the United States Army, defining kerosene, require a flashing point between 135° and 150° Fahrenheit, and a hydrometer test of 48° Baume (specific gravity 0.7865).

Lanterns The first official tabulation of the causes of fires, which was undertaken by the Associated Factory Mutual Insurance Companies, was an investigation of the fires caused by lanterns; and the fact was disclosed that there was a large number of fires with heavy losses attributed to broken lanterns. This led to an examination of all lanterns in mill use, and it was found in every case that the lanterns were badly made, liable to melt at the joints, and insufficiently guarded; as a result the safety lantern was speedily developed.

Lanterns should be strongly constructed of metal with proper guards to protect the chimney. A common fault is the removable bottom for filling which may get loose and drop out. Numerous so-called safety lanterns are on the market, some of which have given good service, especially for the watchman's use. Numerous fires have been caused by broken or defective lanterns and the hazard deserves greater attention than it ordinarily receives. Only approved lanterns such as shown by Fig. 283 should be allowed.

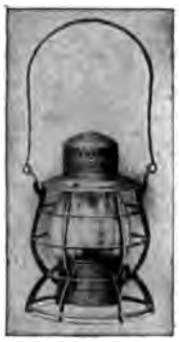

Fig. 283. Approved Watchman's Lantern

Kerosene Oil Pressure Systems. These devices used to supply kerosene vapor lamps with oil under considerable pressure are regarded from an insurance viewpoint as much more hazardous than ordinary kerosene lamps. Where used, the tank should be located outside of the building, and the oil should conform to the requirements established by law for kerosene.

Summary. The following are the most important features governing the installation of all kerosene devices. Supply tanks should be located outside of building. Special permission should be given for any inside installation. Lamps should be carefully located three feet or more from combustible material, and not used in the vicinity of inflammable dust or gases. They should be located so that the burners will be thirty inches or more from the ceiling and be provided with metal heat deflectors not less than six inches in diameter, rigidly secured to the frame. Careful rules are prescribed for the nature of distributing tubes and methods of installation. Only approved devices should be allowed.

Alcohol Lighting. In the opinion of many people, the alcohol lamp is much safer than the kerosene lamp, as burning alcohol is readily extinguished by water which mixes with it in all proportions. Such, of course, is not the case with kerosene as the throwing on of water only serves to spread the fire. Alcohol lamps give off much less radiated heat than kerosene lamps of equal candle power. The principle on which they operate consists in the fact that the alcohol may be vaporized and then burned in the form of gas. As the vaporized alcohol burns with a non-luminous flame, a mantle must be employed and this enhances the value of the light. Since the advent of tax free or denatured alcohol, this liquid has superseded the use of ordinary ethyl or grain alcohol for purposes of fuel for lighting. Methyl or wood alcohol should not be used for this purpose. It is not thought that the introduction of the denaturing ingredients (10 parts methyl alcohol and one-half part of benzine to each 100 parts by volume of ethyl alcohol) has any material effect upon the well recognized characteristics of ethyl alcohol. For a full discussion of the comparative hazards of volatile and inflammable liquids see page 503 and following.

Typical Alcohol Burner. The essential parts of a mantle alcohol burner consist of a small alcohol reservoir pump, the suction wick, the alcohol vaporizing tube, V-shaped in form, and the mantle. Just below the mantle is a small circular shaped asbestos lined copper channel, in which a little alcohol must be ignited to light the lamp. The necessary alcohol is supplied from the reservoir by means of the pump. The burner is shown in Fig. 284 and the pump may be seen in front of the wick. The suction wick in this lamp merely brings the alcohol by capillary attraction to the vaporizing chamber or tube, where it is burned as gas. After the first pre-heating by burning the small amount of alcohol, the operation is automatic. The wick is not consumed and does not char. No free carbon is deposited in the combustion of alcohol, which is an important fact in its superiority over kerosene. The lamp is lighted as follows: The vapor screw valve (shown at right side in Fig. 285) is opened by unscrewing it, and the spring lever (shown at left side in illustrations) is pushed down to operate the pump. The alcohol so brought up to the igniting channel is lighted with a match through the small opening above the spring lever. In about thirty seconds the heat so produced vaporizes the alcohol furnished by the suction wick. This vapor burns as a gas, making the mantle white hot, after which the lamp burns automatically.

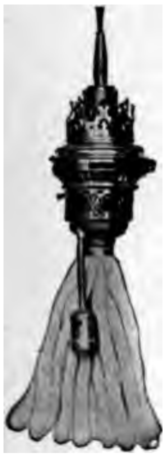
Fig. 284. Alcohol Lamp Burner

Electric Lighting Systems. When properly installed, statistics show that a remarkably small percentage of fires is caused by electricity, and electric light is really the safest illuminant known. All new systems, additions, and revisions of old work should be installed in strict conformity to the requirements of the National Electrical Code,* which is today almost universally used and followed in all parts of the country. The chief difficulty comes in changes to the equipment and abuse of the system after it has been installed. Many electrical fires are caused from employing non-trained labor to install temporary work and by the carelessness of plumbers, carpenters, and

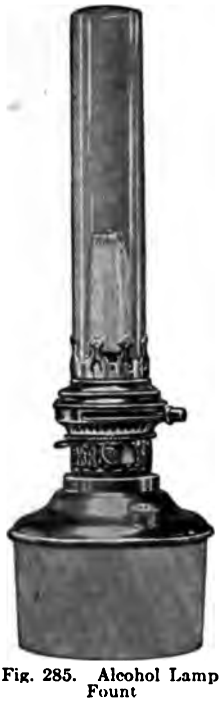
Fig. 285. Alcohol Lamp Fount

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*For a detailed discussion of Electricity as a Cause of Fire, and for the Proper Installation of Electrical Equipment, the reader is referred to Underwriters' Requirements, Parts 1 and 2.

other mechanics who in this way often undo the work that has been previously well and safely done.

Inherent Hazards. There are, however, certain inherent hazards which are inseparable from the normal use of electric systems. Lamps of all types produce heat, particularly as they get old. An incandescent lamp will char paper or cloth and has been known to ignite wood. The electric arc is one of the most intense sources of heat known to science. An ideal lamp would convert all the energy of the electric current into light and waste none in heat. This device has not yet been produced and possibly never will be. It is an interesting fact, however, that electric lamps produce less heat in proportion to the light given than any other common form of illuminant.

Old lamps should be removed. In all cases where there is a possibility of their coming in contact with merchandise, they should be protected with wire cages to prevent this occurrence. Where there are inflammable gases or flying material present, the lamps should be inclosed by another globe, and protected against breakage by a wire bonnet, as shown in Fig. 286. Flexible cords should not be hung on nails, or on gas, water, or steam pipes, as insulations are liable to become worn and short circuits result; also knots should not be tied in them.

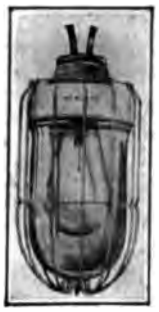
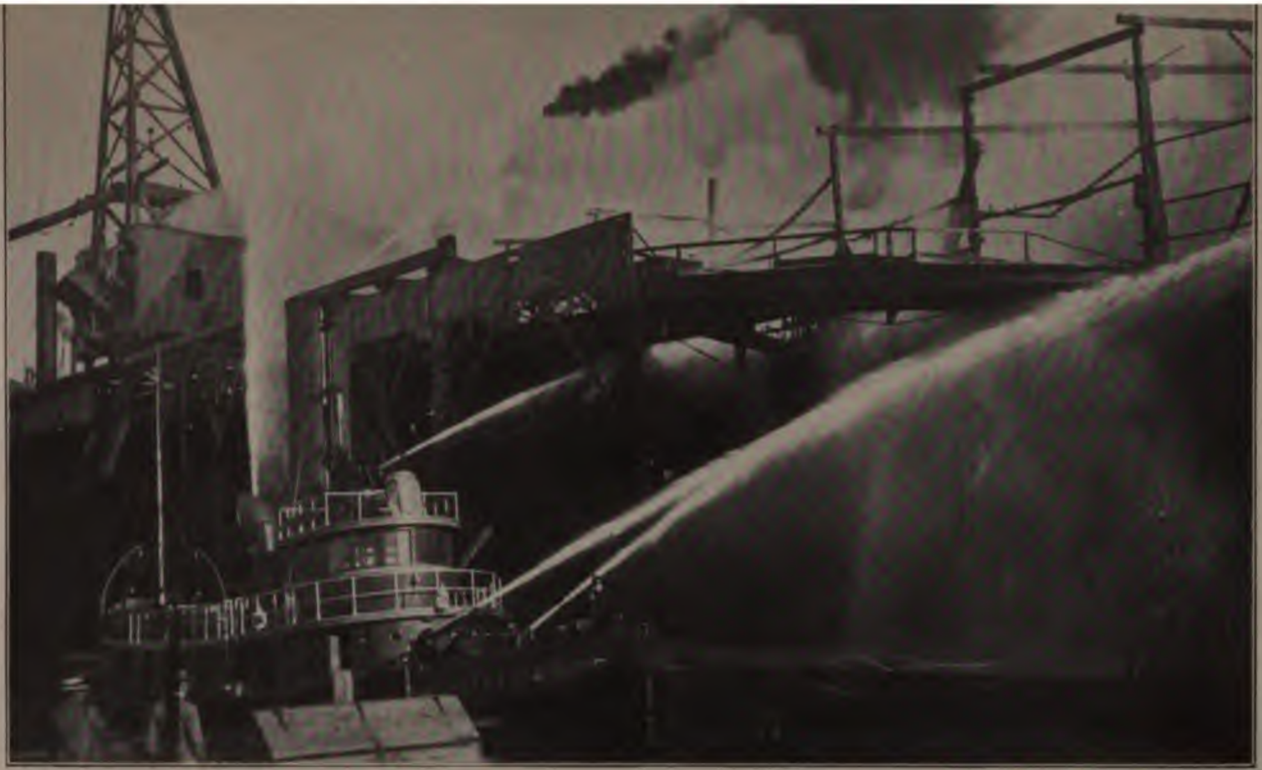


Fig. 286. Electric Globe, Glass and Wire Protection

Unavoidable Dangerous Conditions. There are certain dangers arising from purely accidental occurrences which cannot well be avoided by excellence of construction and installation or by careful use. Mechanical injury to wires or apparatus may result in dangerous conditions. Lightning may strike outside lines and be conducted into the building; or line wires may become crossed with high tension lines, thus introducing voltages much in excess of what the insulation of the equipment can take care of. The only precautions which can be taken are ordinary protection against mechanical injury, use of lightning arresters and fuses, and care in running pole lines.

Acetylene Lighting Systems. *Calcium Carbide.* By heating a mixture of powdered coke and limestone in an electric furnace at a high temperature, calcium carbide is formed. When treated with



FIRE-BOAT WORK ON LUMBER YARD AND WHARF AT ALBANY STREET, BOSTON

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ASTOR, LENOX AND
TILDEN FOUNDATIONS

er this is decomposed with formation of acetylene gas. Calcium bide was first prepared on a commercial scale in 1892. Acetylene , as such, was known and prepared in another manner in 1836. cium carbide is in itself non-explosive and non-inflammable; but ng to its peculiar properties when brought into contact with er or dampness, it is a somewhat hazardous material, and the owing rules which have been made governing its handling and age, should be strictly observed.

Calcium carbide in quantities not to exceed six hundred (600) nds may be stored, when contained in approved metal packages to exceed one hundred pounds each, inside insured property, vided that the place of storage be dry, waterproof, and well ven- ted; and also provided that all but one of the packages in any one lding shall be sealed and the seals shall not be broken so long as re is carbide in excess of one pound in any other unsealed pack- s in the building. Conditions governing storage of greater quan- es, specific details of container, etc., are given in the Rules and quirements on this subject.

Calcium carbide in quantities in excess of six hundred (600) nds may be stored above ground in detached buildings used lusively for the storage of calcium carbide, in approved metal kages, and such buildings must be constructed dry, waterproof, well ventilated.

Packages to be approved must be made of metal of sufficient ngth to insure handling the package without rupture, and be vided with a screwed top or its equivalent. They must be con- cted so as to be water- and air-tight without the use of solder, and spicuously marked "CALCIUM CARBIDE—DANGEROUS IF T KEPT DRY."

Carbide and Water. When water and calcium carbide are ught together, sixty-four parts of calcium carbide and thirty-six ts of water mutually decompose, evolving twenty-six parts of tylene and seventy-four parts of sludge, or slaked lime. A pound commercial carbide yields about five cubic feet of gas. As siderable heat is generated in this reaction, it is highly desirable ave the water greatly in excess of the theoretical quantity needed, cetylene tends to change under heat and polymerize into other esirable compounds; the ease of removing sludge is also enhanced.

Acetylene Gas. Acetylene has a characteristic odor of garlic and burns with a fine white flame. It is highly explosive when mixed with the right proportion of air. Scientific investigators have found the explosion to be most violent in a mixture of about nine parts of air and one part of gas, with an explosive range from three per cent to eighty-two per cent of acetylene in mixture with air. Experiments conducted under normal and practical conditions of use showed the range to be from three per cent to about thirty-three per cent, the most violent mixture consisting of twelve parts of air and one of gas. The maximum amount of gas which will form an explosive mixture is of little importance, and the total explosive range in considering any gas, is likely to be misleading. Acetylene gas is lighter than air, its specific gravity being 0.898. Owing to the pungent odor of acetylene, it can very readily be detected before there is a sufficient amount in a room to form an explosive mixture, and physical discomfort will be experienced both before an explosive mixture or a poisonous mixture has been reached. In this respect, it is much superior to city gas.

Acetylene Apparatus. Acetylene apparatus is now almost universally made under the strict surveillance of the Laboratories, and only approved machines should ever be permitted for use, if not in violation of any state law or local ordinance, and if the company insuring the property consents to the same in writing on its policy. Where used, care should be taken to see that these machines are installed throughout in accordance with the Rules and Requirements. Acetylene gas machines, especially in closely built-up districts, should be installed outside of buildings in properly constructed generator houses. The installation of acetylene gas machines inside of buildings is prohibited in certain districts by legal authorities. It might be added that the experience of underwriters throughout the United States with modern and permitted acetylene installations has been at least as favorable as that with the form of illuminant which they have replaced. The only territory where the Underwriters having jurisdiction do not now allow installations within the building is New England and the southeastern states.

Acetylene Generators. The function of an acetylene generator is a comparatively simple one. It provides for the bringing together of the water and the carbide, washing and filtering the gas, storing it to a certain extent, and delivering it under a small pressure to the service pipe for distribution. Acetylene generators are divided into two general classes, automatic and non-automatic. In the automatic machine the gas is generated as it is used, the quantity generated being automatically governed by the rate of consumption. In the non-automatic machine a definite quantity of gas is generated at a fixed rate and stored. The former type is used for all small installations such as house lighting plants. The latter type is used for large plants, such as village lighting systems. In this discussion we are interested chiefly in the automatic generator as a private lighting plant for the country home.

Features of Design. The most important feature to be considered in the design of an acetylene generator is that of cool generation. When the carbide and water unite to form gas, violent chemical action occurs with the liberation of large quantities of heat. If this heat be localized, dangerous temperature rise is liable to occur. The carbide in such a type of generator would not give its full quota of gas and the burners would soon clog up, due to its impure quality. When water is fed into the carbide it is evident that there will be more or less localization of heat, with consequent heat generation. Hence the most rational method would be to feed carbide in small, well regulated quantities into a large body of water, where the heat would be quickly transferred and dissipated. The water to carbide feed type of generator, designated as the "water feed" generator, is rapidly disappearing from the market, and the carbide to water or "carbide feed" generator is now almost universally used.

Classes of Generators. The carbide feed generators are divided into the following classes: (1) the "direct feed," feeding the carbide by gravity into the water by opening the feed valve which is operated directly by the gas holder bell; (2) the "indirect feed," the gas holder bell operating a feeding mechanism which carries the carbide forward to the feed point where it falls into the water; (3) the "independent feed," the feed valve being operated by a clockwork or motor mechanism controlled by the gas holder bell; (4) the "indirect independent feed,"—a motor or clockwork being controlled by the gas holder bell operating a feed mechanism which carries the carbide forward to the feed point.

Essential Parts. The acetylene gas machine consists of two essential parts,—the generator proper and the gas holder, or gasometer, as it is often called. The gasometer by the rise and fall of its gas bell regulates the quantity of gas generated and also serves as a pressure equalizer, supplying the gas to the mains at a constant uniform pressure.

Typical Carbide Feed Machine. A typical carbide feed machine is shown in Fig. 287. The carbide is fed from hopper *Q* into the body of water *G*. Gas is generated and passes out into the water seal *E*.

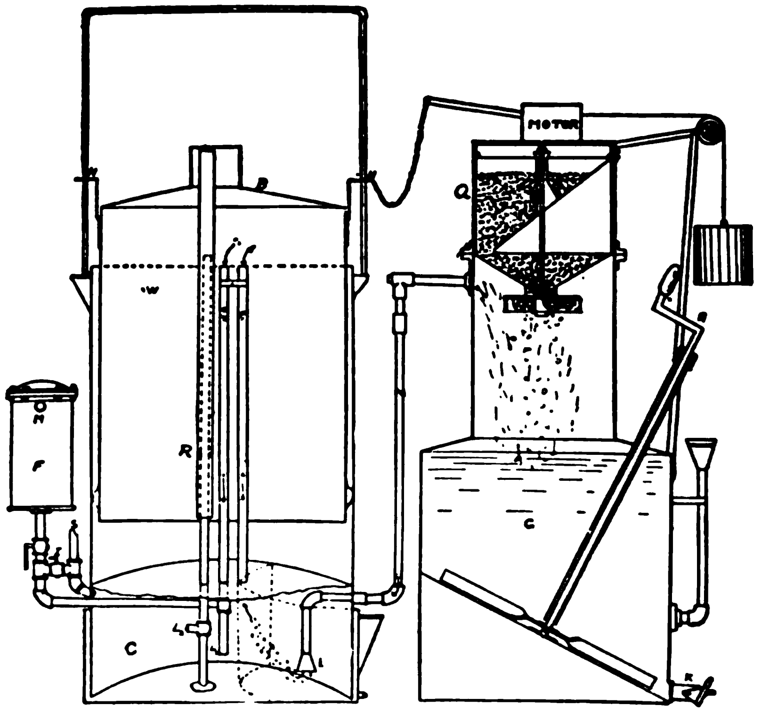

Fig. 287. Details of Typical Acetylene Generator

This chamber is partially filled with water. From *E* the gas passes through the pipe *P*, into the gasometer. The gasometer bell is closed at the top and open at the bottom. It rests in the body of water whose surface is at *W*. As gas enters, the bell rises, thus acting as a storage tank for the gas. The telescopic action of the bell is guided by the rods *H*. The gas bell supplies gas at a virtually constant pressure through pipe *P* and filter *F* to service main at *M*. When the bell rises to a certain height, it stops the weight motor and hence carbide feed. When the bell drops below this point, carbide is again fed into the water until the bell rises above this point. The chamber C is of course filled with water to the same height as the water in E. Hence any undue pressure in gas bell will cause gas to bubble through open connection at L into chamber C. If the gas bell should accidentally rise too high, due to a fault in the mechanism or undue after generation, the gas will enter telescopic tube at R and escape through L into C. The chamber C is connected with the open air by the escape pipe S. The by-pass valve I is used when it becomes necessary to empty gas bell for cleaning or repairs. The generator is cleaned by agitating the contents of G with the mixer A. The mixture of slaked lime and water is then drawn off from the sludge-cock K. The handle A is water-sealed as shown, to prevent the escape of gas around same.

Portable Table Lamps. Class D. Only approved lamps should be allowed. This form of lighting has not been exploited to any extent.

Every owner of an acetylene generating system should be presented with the following facts, and pains should be taken to see that he is duly impressed.

CAUTIONS*

1. Calcium carbide should be kept in water-tight metal cans, by itself, outside of any insured building, under lock and key, and where it is not exposed to the weather.

2. A regular time should be set for attending to and charging the apparatus during daylight hours only.

3. In charging the generator chambers of water-feed machines, clean all residuum carefully from the containers and remove it at once from the building. Separate from the mass any unslaked carbide remaining and return it to the container, adding new carbide as required. Be careful never to fill the container over the specified mark, as it is important to allow for the swelling of the carbide when it comes in contact with water. The proper action and economy of the machine are dependent on the arrangement and amount of carbide placed in the generator. Carefully guard against the escape of gas.

4. Whenever recharging with carbide always replenish the water supply.

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*Failure to observe the above cautions is liable to endanger life and property.

5. Never deposit residuum or exhausted material from water-feed machines in sewer pipes nor near inflammable material.

6. Water tanks and water seals must always be kept filled with clean water.

7. Never install more than the equivalent of the number of half-foot burners for which the machine is rated.

8. Never test the generator or piping for leaks with a flame, and never apply flame to an outlet from which the burner has been removed.

9. Never use a lighted match, lamp, candle, lantern, or any open light near the machine.

10. See that the entire installation is in accordance with the rules of the National Board of Fire Underwriters, a copy of which will be furnished by your insurance agent; and obtain from your contractor a written guarantee that these rules are complied with.

Dissolved Acetylene. When acetylene is compressed and forced into a tank filled with some porous material saturated with some liquid such as "acetone," it seems to lose the explosive properties that it ordinarily possesses when under pressure. Acetone dissolves twenty-four times its own bulk of the gas at ordinary temperature and pressure, and the quantity dissolved increases directly with the pressure applied. As the pressure is released, the gas escapes and is delivered cool and dry to the burners. Dissolved acetylene finds its application with yachts, motor cars, railway headlights, and railway car lighting. For ordinary house lighting, it is entirely out of the question; acetylene can be provided for stationary purposes by generators so much more economically that dissolved acetylene finds no application here.

Prest-O-Lite. The well-known Prest-O-Lite tanks are cold drawn seamless steel cylinders, without lining, coppered or nickeled for outside finish, with valve and stop cock at one end and a fusible plug at the other. The purpose of the plug is to allow the gas to escape and flow, in event of a fire. Tanks are subjected to a test pressure of 500 pounds and then filled with asbestos. The acetone is then put in, until the asbestos has absorbed all it will; and last of all, the acetylene gas is forced in under about 225 pounds pressure and absorbed by the acetone.

The description above applies only to tanks, the serial numbers of which are 40,000 and up. Serial numbers below 40,000 are made with wick packing and are not explosion-proof, due to the fact that the packing is generally not well put in, and thus leaves small spaces of gas that are explosive. The hazard is practically *nil* from those tanks bearing serial numbers from 40,000 up.

The handling of empty tanks, however, introduces an explosive hazard. Frequently tanks are returned by the user with small quantities of gas remaining in them; and if the valves are not tightly closed, the gas will escape, forming pockets in the atmosphere. These pockets will absorb enough atmosphere to make them highly explosive, and the presence of a spark is all that is required to set them off.

Liquid Acetylene. Under compression acetylene becomes most hazardous, increasing with the pressure to the point of liquefaction. At a temperature of 68° Fahrenheit and about 597 pounds per square inch pressure, acetylene may be liquefied. This liquid is of a violent explosive nature and does away with all thought of storing the gas by this means. No one has ever succeeded in getting an explosion from pure acetylene gas at a pressure under one atmosphere. Since the ordinary pressure of the gas under service is but a few ounces at most, it is evident that there is absolutely no danger to be apprehended from this source unless it is mixed with the necessary amount of air.

The use of liquid acetylene is not permitted under any conditions granted by underwriters, and is prohibited by law in many places.

Gasoline Lighting. The classifications given in the Rules and Requirements for the Construction, Installation, and Use of Gasoline Vapor Gas Lighting Machines, Lamps, and Systems are as follows:

Class *A*—Machines having outside carbureters.
Class *B*—Machines having inside carbureters.
Class *C*—Systems having outside tanks and inside flame-heated generators.
Class *D*—Gasoline vapor lamps.
Class *E*—Especially hazardous systems.

Class *A* and *C* systems are those which are most commonly met in service today.

No specific record of fires due to gasoline lighting systems is available. General impressions in insurance circles are that the record has not been a bad one. There have undoubtedly been a great many fires due chiefly to the handling of gasoline; but when it is considered that other illuminants which are supplanted by gasoline devices have their own peculiar hazards, the record has not been sufficiently bad to cause any general apprehension of danger.*

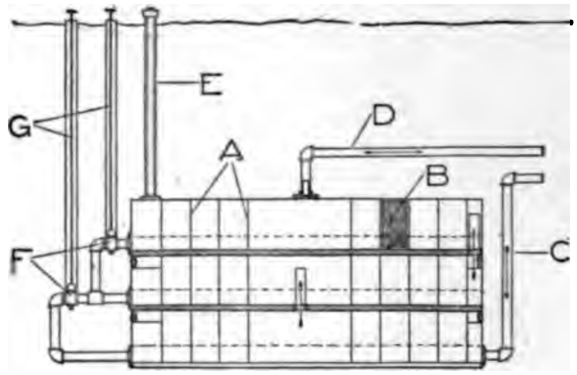

Fig. 288. Gasoline Carbureter—Section Class A

Class A System. A section of the carbureter used in this system is shown in detail in Fig. 288 and a plan is shown in Fig. 289. The carbureter is located outside and underground. The machine shown is constructed in three layers, which are in effect separate carburetors arranged in series. Most carbureters are probably of the one-cell type, although in some instances machines are made with as many

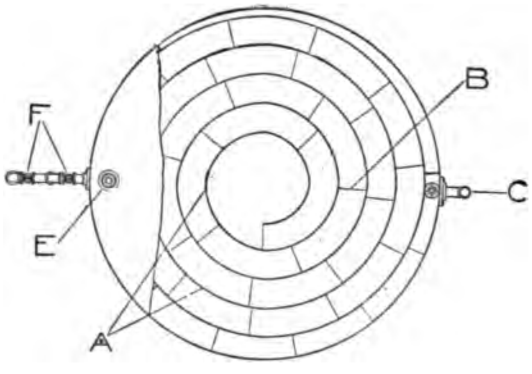

Fig. 289. Gasoline Carbureter Plan—Class A

as four of these sections. In each there are usually metal or wooden frames supporting canton flannel, canvas, burlap, or similar material, on to which gasoline is drawn by capillary action from the supply which lies upon the bottom of each section or layer. Fig. 289 has had the top cut away, partly to show spiral partitions (*A* in each view) through the use of which a large amount of gasoline surface and many fabric areas (one shown as *B* in each view) are exposed to the air passing through the carbureter. This air under moderate pressure enters the lower compartment through the pipe *C*, passes spirally over the gasoline surface and through the saturated fabric, then upward into the next section, as shown by arrow, through this one and finally emerges from the top of the upper cell at the point *D*, heavily charged with gasoline vapors. *E* is the concentric fill and vent pipe. As in filling, gasoline passes down through the inner pipe, the gas which is driven out by the fresh gasoline leaves the carbureter through the annular space between the two pipes. Of course the carbureter must be shut down to permit refilling. The transfer

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*The author is greatly indebted to the investigations of Mr. H. M. Forster, on Gasoline Lighting Systems, the results of which were published in a Quarterly of the National Fire Protection Association.

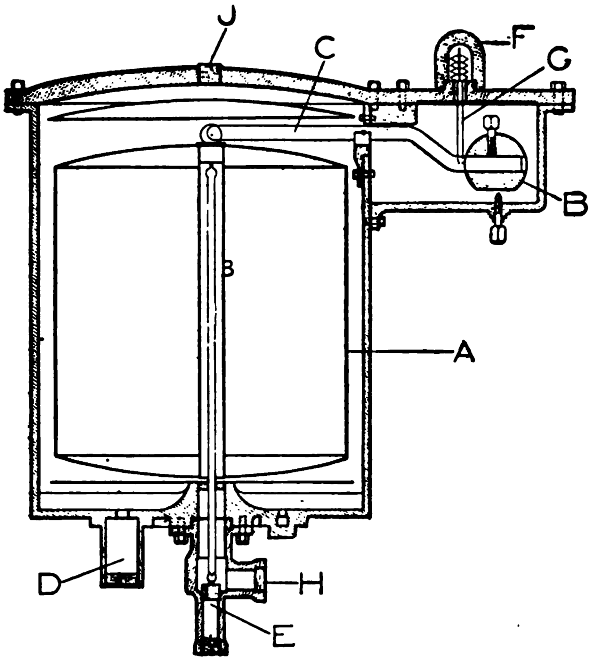

Fig. 290. Details of a Gasoline Mixer

valves *F* are controlled by rods *G* which extend to the ground level. They are protected by pipes.

The *blower* is usually operated by a weight or by a water-wheel. The ordinary blower consists merely of a drum revolving in a snugly fitting cylinder which is partly filled with water; and it compresses the air to a moderate pressure, such as two to three inches of water-gauge. It supplies air only as rapidly as the system requires it.

The *mixer*, details of a well-known one being shown in Fig. 290, is simple in operation. The float *A* is a cylinder of light weight metal entirely sealed as far as joints are concerned. It is practically balanced by the weight *B* operating on the other end of the lever arm *C* which rests upon a knife edge. *D* is the point at which the rich gas enters from the carbureter. The float *A* is lifted by this heavy gas which has a greater gravity than the air; and as it rises, the air port *E* is opened, admitting air from the blower, reducing the richness of the mixture and gradually restoring a balance which results in the fall of the weight and the closing of the air port. At the point *F* a cap may be unscrewed and small rider weights placed upon or taken from the pin *G*. Through increasing or reducing the number of weights, delicate adjustments in gas pressure are obtained. The observation port *H* enables one to view the operation of the air valve. The whole apparatus is in a heavy cast-iron box without gas openings other than the small one *G*, which is only opened at intervals. Furthermore, the actual orifice at this point is very small. The mixed gas leaves the device at *J*.

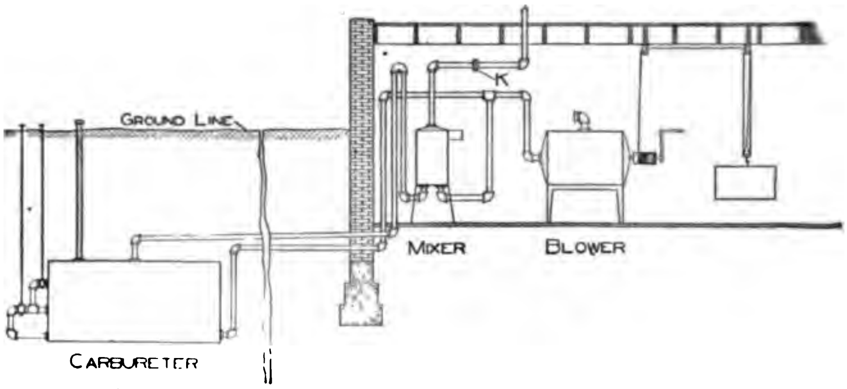

Fig. 291. Complete Installation Gasoline Lighting System—Class A

Fig. 291 illustrates a complete installation, giving the relative locations of the various parts of the equipment and showing the pipe arrangement. Here the flash-back arrester K is shown between the mixer and the service connection. The arrester consists of a flanged fitting containing one or more layers of fine mesh brass gauze. The Underwriters' Rules specify that this shall be not less than twenty mesh per inch; but usually several layers of a coarser gauze are used in preference to one layer of a finer mesh. The theory of the arrester is that any flash-back in the piping would be prevented from entering the mixer or carbureter where larger gas volumes are present. The gas in the ordinary Class A system is probably explosive; that is, it would be so in a large volume but not necessarily so in small pipes which have a large cooling surface in proportion to their contents.

The *hazards of Class A systems* may be stated as follows: These machines, which do not introduce liquid gasoline into the building, are regarded from an insurance viewpoint as constituting the least dangerous type of gasoline gas machines. It was at one time customary to place carbureters in brick vaults. Any gasoline leaks or overflow resulted in gas accumulating at the bottoms of pits, and several serious accidents resulted when this ignited. Nowadays carbureters are well painted and buried. This is obviously the safest method.

Piping conveying gas from the carbureter to the building, as well as air from the blower to the carbureter, is required to slope one inch in ten feet from the building wall toward the carbureter itself. The purpose of this is to permit any gasoline which may be precipitated out of the gas to drain away from the building back into the carbureter.

Gas and air piping between carbureter and building must reach a greater altitude in the building than the top of the fill-pipe outside; so that gasoline could under no conditions be forced into the building by gravity which might be brought about by the carbureter being overfilled or slight head placed on the same by the gasoline tank wagon or barrels used to replenish the supply. In Fig. 291 the arrangement is clearly shown. The rule was incorporated only after accidents had occurred due to the gravity feed of gasoline into buildings. The flash arrester, shown in the service pipe near the mixer in Fig. 291, is needed for reasons noted previously.

Class B System. This system has a small inside carbureter consisting usually of steam coils on to which gasoline is sprayed, but an outside underground storage tank. Gasoline is pumped up to the carbureter by various mechanical means, and the excess in each case is returned by gravity to the storage tank. Power-driven blowers are generally employed, and the ratio of air to gasoline pumped can be so adjusted that the richness of the gas will be uniform. These machines are used largely for power gas development and are met but infrequently in the field. Several serious fires are attributed to improperly designed fuel gasoline gas installations.

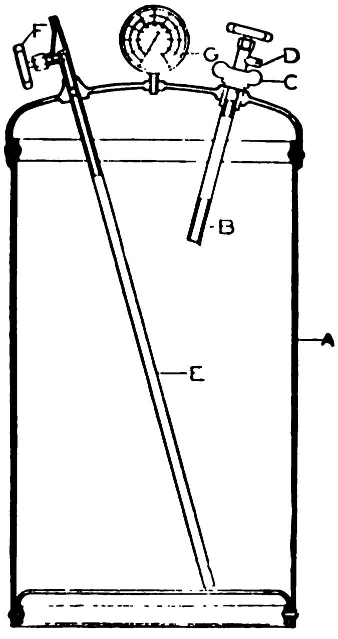

Fig. 292. Gasoline Tank—Class C

The *hazards of Class B systems* may be stated as follows: These machines are regarded from an insurance view point as more dangerous than those having outside carbureters, owing to the fact that they introduce gasoline in liquid form and manufacture gas inside the building. The same general rules as in Class *A* apply; and, in addition, ample return pipe is needed to carry excess gasoline back to the storage tank. In this case a one-inch pitch in five feet is prescribed by the Rules. The carbureter gasoline capacity is limited to one quart, and fire heat is not allowed for vaporizing purposes; hence, a carbureter of this type is mildly hazardous.

Class C Systems. There are two divisions to this classification; the first is the individual, and the second the common generator type. Both, however, depend upon a supply tank, and such a one is shown in Fig. 292. The shell *A* is of galvanized steel or of copper, and of sufficient strength to withstand the one-hundred-pound five-minute test which is set forth in the Underwriters' Rules. The gasoline capacity must not exceed six gallons, this being determined by the location of the end of the seal tube *B* through which the gasoline is poured. The fill cap *C* is normally combined with an air inlet valve

D. After *C* is screwed down, a foot pump is attached to *D* and an air pressure of from fifteen to forty pounds placed on the tank. The gasoline leaves the tank through the tube *E* and is controlled by the valve *F*.

The *working pressure* which has been advocated as most effective is from six to forty pounds. The Underwriters' Rules place the limit at fifty pounds and the pressure gauge *G* is required. The larger the total capacity of the tank, the slower the drop in pressure, and some manufacturers make the air capacity of the tank when full, about equal to the gasoline contained. Others economize on tank size and cut down the air space. Such a system requires more frequent pumping up to maintain an effective pressure.

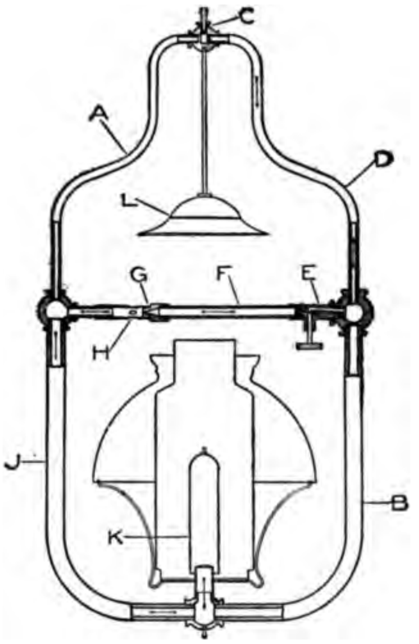

Fig. 293. Individual Generator Lamp—Class C

The *standard individual generator lamp* is shown in sectional view in Fig. 293. The arrows show the path of the gasoline and the gas. Two tubes, *A* and *B*, are useless from an operating standpoint and are stopped off at one end. They are used to add strength and symmetry to the appearance. The connection *C* at the top is attached to a hollow wire feeder, and gasoline passes through the tube *D* to control valve *E*. This, in the lamp shown, acts both as a regulating and as a shut-off valve; but often two separate valves are provided. The generator tube *F* is filled with brass gauze or asbestos wicking to assist in holding heat; and as the gasoline passes through this tube, the intense heat from the mantle immediately below causes it to issue from the small orifice *G* in the form of vapor. The injector action of this spray draws air in through the air inlet sleeve *H* and the mixture passes down gas tube *J* to the mantle *K*. *L* is a heat deflector. To start a lamp of this kind an alcohol heater, consisting usually of an asbestos pad, is placed immediately below the generator tube; and when this has become sufficiently heated, gasoline is slowly turned on, gas over mantles usually igniting from the burning alcohol. The lighting time required is not great; perhaps a minute being the average.

A *typical common generator* is shown in Fig. 294. Gasoline enters at *A*, passes through the filter *B*, is turned on or off by shut-off valve *C*, and then enters the generator chamber *D*. The alcohol cup *E* is used to heat the generator, after which needle valve *F* is opened slowly. The spray of gasoline vapor issues from tip *G*, draws air through pipe *H*, the mixture is made in the mixing tube *J*, and the finished gas passes into the piping of the system which screws into fitting *K*. As soon as gas is being generated, valve *L* is opened and gas taken through the tube *M* to sub-flame *N*. This is usually a slotted burner similar to one used on gas stoves, and surrounds the generator. The deflector shield *P* helps drive heat against the generator *D*. With this system a small amount of the gas made is used to maintain generation. In the case of the individual generator lamps, the heat of the mantle is utilized; but with a common generator system this is obviously not possible.

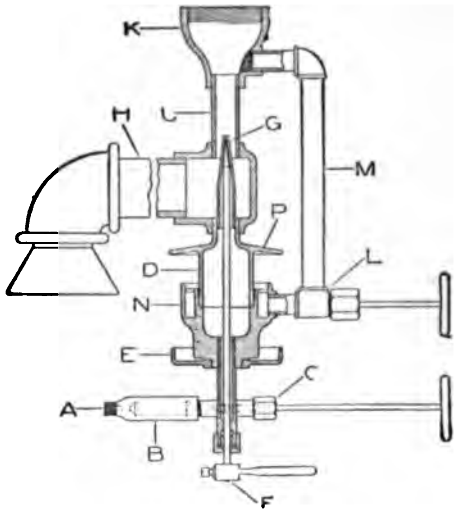

Fig. 294. Common Generator—Class C

The air intake pipe *H* must be carried to the outside of the building with proper pitch and be screened so that any liquid gasoline which may issue from the needle tip *G* will be automatically conducted from building. This can, of course, happen under certain conditions, but the occurrence is infrequent. The entire generator must be enclosed in a double metal case having at least one-inch air space between the walls, and there must be a tight door with a latch. Furthermore, the generator must be placed at least a foot from combustible material, such as shelves or counters.

Distributing tubes are supplied in the form of hollow wires to conduct gasoline from the supply tank outside of the building to all of the individual generator lamps, as well as to the common generator of a system. These wires are seamless copper or brass with an inside diameter from three-thirty-seconds to one-eighth inch, and of sufficient thickness to withstand all operating conditions. As a matter of fact some successfully pass a one-thousand-pound-per-square-inch test. They must be supported at intervals not greater than six feet, protected where passing through floors or on side walls, and not used to support lamps. The joints are made with ground seated unions or brazed. A fifty-pound pressure test is required for the completed installation.

Distributing tubes used with common generator systems are usually two inches in diameter and made of sheet metal with soldered, locked, longitudinal seams. Brass or wrought iron is permitted, but infrequently used, because of the greater cost. Brass fittings between sections are required, slip joints not being permitted.

The *hazards of Class C systems* may be stated as follows: These systems are regarded from an insurance viewpoint as more hazardous than the systems in Class *A* or Class *B*, owing to the fact that they introduce gasoline in liquid form into the building and are provided with flame-heated generators. Particular attention is called to the rule requiring all tanks used in connection with these systems to be installed outside of the building. Outside supply tank and storage of gasoline is essential.

Installation of lamps in places where inflammable material exists immediately below them is dangerous; and lamps should in all cases be placed above unoccupied sections of floor, so that a drop or two of burning gasoline or alcohol could not readily start fire. Individual generator lamps should under no conditions be hung directly upon the hollow wires. This is a practice which is found very frequently in the field. The effect on the thin copper or brass wire, owing to the weight of the lamp, and to the vibration which usually exists with systems of this kind, is decidedly bad. Ceiling plates and rods or chains to carry the lamp, independently of the wire, are required by the Rules and should be installed. Proper joints in hollow wires, as well as supports and protection for the same, are essential. The fifty-pound pressure test of the completed individual generator system is important in that it will show up any existing leaks.

Common generator cases, although made with double walls having air space, should be placed as far from combustible material as possible. The Rules specify that a clear space between floor and ceiling shall be maintained, and that no combustible material shall be brought closer than one foot on either side.

Outside sloping air intake pipes for common generators are needed to carry raw gasoline which may get into the mixing-tube to the outside of the building. The down-turned fitting with screen is also necessary if safety is to be assured.

Initial generation with gasoline is strictly forbidden; alcohol is required.

Class D Systems. There are pressure and gravity lamps manufactured under this classification. The principle of operation is quite similar to the individual generator lamp shown in Fig. 293. With pressure lamps the bowl, containing at a maximum two quarts of gasoline, is placed immediately below the frame; and air pressure is placed on the gasoline with a hand or foot pump in a manner similar to the storage tanks for the Class *C* systems. These bowls have seal tubes to limit the gasoline capacity and insure air space. The gasoline from this pressure bowl passes up one side of the frame through the generator, and the gas passes down the other tube to the mantle. The bowls are substantially constructed, and even more severe pressure test requirements pertain than in the case of the Class *C* tanks. The bowls must withstand a two hundred-pound pressure test maintained for a period of five minutes; and an intermittent hydrostatic test lasting one hour with a pressure of one hundred pounds per square inch on for five-minute periods and off for one-minute periods during the hour.

Gravity lamps have a bowl at the top of the frame of a capacity not to exceed two quarts. The feed of the gasoline, down through the tubing which supports the lamp, is by gravity; the effective head usually being 30 to 36 inches. The gasoline passes through a generator above the mantle in the customary manner and the gas is conveyed to the bottom of the lamp and consumed. Their gasoline supply is in close proximity to the flame and they may frequently be refilled inside of the building. The

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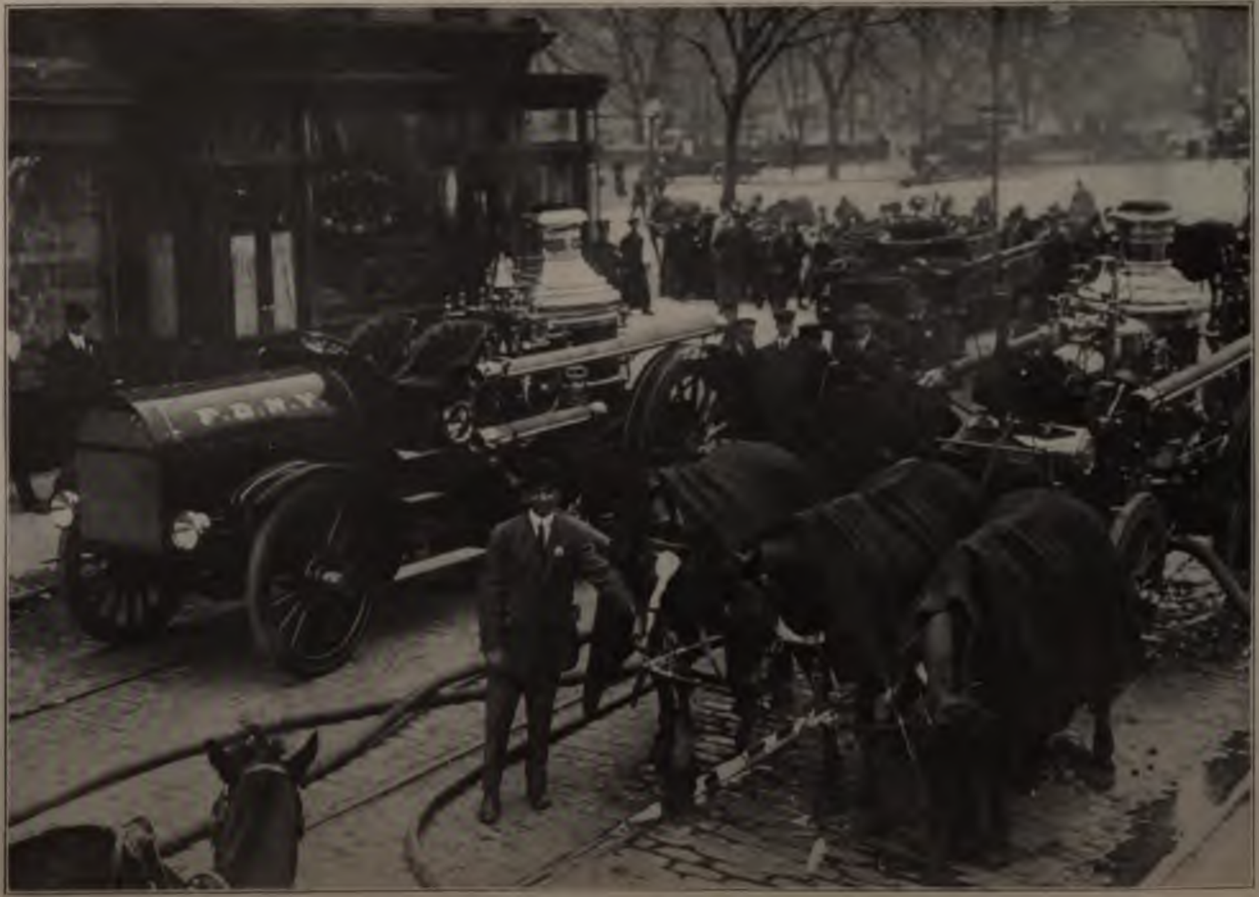
ASTOR, LENOX AND
TILDEN FOUNDATIONS.



PASSING OF THE HORSE IN UP-TO-DATE FIRE-FIGHTING WORK

The Fire Service Demanded in Every Large City Makes It Impossible for the Horse-Drawn Appliances to Compete with Those Which Are Motor Driven lamps of this type are no longer being used in large numbers in this country.

The *hazards of Class D systems* may be stated as follows: These lamps are regarded from an insurance viewpoint as even more dangerous than the systems covered in Class *A*, Class *B*, or Class *C*, owing to the fact that their gasoline supply is in close proximity to the flame and that they may frequently be refilled inside of the building.

Note particularly that gasoline lamps should be hung at a safe distance from ignitible material, woodwork, etc.

The approved list covers pendant and bracket lamps only. No portable, hand, or table lamps are permitted.

Filling gravity bowl lamps while the light is burning naturally invites disaster.

Filling gravity bowls too full may result in sufficient expansion of gasoline taking place, when the heat of the mantle rises to the ceiling, to cause some of it to overflow, with fire as the result.

Class E Systems. Gasoline vapor gas lighting machines or systems having gasoline tanks inside of the building introduce especially dangerous features. Up to the present time only one such system has been accepted, although the fire record has not been as bad as might be expected. It is thought, however, that devices of this classification will be little used, and a detailed description will be omitted.

Gasoline Lighting Hazards in General. In gasoline vapor lighting systems, as in other cases where gasoline is used, the hazard lies chiefly in having the liquid about. At ordinary temperatures gasoline continually gives off inflammable vapor, and a light which is some distance from any material may ignite it through the medium of this vapor. The vapor from one pint of gasoline will make two hundred cubic feet of air explosive. It depends upon the proportion of air and vapor whether it becomes a burning gas or a destructive explosive. The use and storage of gasoline, even with all known precautions, are dangers which should always be recognized. Where permitted it should be surrounded by the most rigid safeguards. The many hazards which can be introduced by faulty design and construction of apparatus need not cause worry, if only those machines or systems which have the approval of the Laboratories are used.

Maintenance. Class *A* machines need little attention; putting a barrel or two of gasoline into the carbureter occasionally and winding up the blower weight at regular intervals are practically all that need to be done; and wherever the water-wheel-driven blower is used, the latter and more laborious part of the maintenance falls away. Class *C* system tanks require frequent filling and pumping up, and the lamps must be generated each time they are lighted. With a common generator system it is only necessary to heat this one device; but adjustment has to be made as more lamps are added or as the number is reduced.

Blaugas. Blaugas is made from the destructive distillation of oil at a somewhat lower temperature than is used where gas is distilled from coal. By a three-stage compressor it is compressed from 60 to 100 atmospheres (900 to 1,500 pounds) and then placed in cylinders, or bottles. The gas is in the liquid form, the liquid consisting of gases which liquefy and also certain gases which are held in the solution. The gas is stable in that it will not disassociate with shock, in this respect being entirely different from liquid acetylene. The cylinders or bottles have been accepted by the Bureau for the Safe Transportation of Explosives and Other Dangerous Articles, severe tests being made by this Bureau by exploding dynamite cartridges at the side of the cylinders and by placing the cylinders on fire and allowing them to heat up until the safety valve, with which each bottle is equipped, opened. The cylinders are made in Germany, are tested to 250 atmospheres (3,750 pounds), and are further tested to 3,200 pounds in this country. Tests show that the cylinders will not burst until pressure reaches over 6,000 pounds. At the subscriber's or consumer's premises, two of these bottles are placed in a metal cabinet on the outside of the building to be lighted, and are expanded into the building through suitable reducing and regulating valves. The high pressure cylinders, together with reducing and regulating valves, are contained in a locked and ventilated metal box.

This system is arranged to run automatically with small expansion tanks, in this box; or non-automatically with larger expansion tanks which are buried or installed in well-ventilated brick or concrete houses when near buildings. The gas itself, after introduction into the house piping, embodies about the same hazards as ordinary city gas, but is under somewhat higher pressure on the house side (being about 12 inches of water column, or one-half pound).

Safeguards. The safeguards on the apparatus are as follows:

(1) To guard against failure of high-pressure reducing valve. Should pressure on expansion tank exceed 120 pounds (tank is tested to 300), a safety valve operates and allows gas to escape to outside air.

(2) To guard against failure of low-pressure reducing valve. Should pressure on house side reach or exceed 40 inches of water (less than 2 pounds), a mercury seal is broken and gas blows to outside air.

(3) All parts which are subjected to high pressure are placed outside buildings.

(4) Cylinders and tanks have a reasonable margin of safety. In case of fire the safety valve on the cylinders would let go and the gas would burn. There would be no explosion under these conditions.

Underwriters' Requirements. It is reasonable to suppose that the gas will replace other methods of lighting which are at least as hazardous, probably more so. Cylinder contains about twenty-two pounds of gas which is equivalent to 300 cubic feet of gas. Burning of one foot of gas is equivalent to 120 c. p. Several Underwriters' associations having jurisdiction allow the installation of this apparatus without any extra charge if it is installed in accordance with the prescribed method, that is, with the apparatus entirely out of the building.

There are other liquid gas systems, but they have not attained great commercial importance except the well-known Pintsch gas so much used by railroads. The hazards are not essentially different from those of Blaugas.

HEATING AND VENTILATION

Heating and ventilating systems of one kind or another are the causes of many fires and the various methods and systems in common use should be understood so that proper rules may be observed and suitable precautions taken to guard against the possibility of fire. Heat is desired mostly for the purposes of cooking and preparing food for human sustenance and of sufficiently warming our houses and buildings to ensure comfort during cold weather.

One of the earliest forms of heating of which we have any knowledge is that of the charcoal brazier, which in the days of the Grecian and Roman civilizations was a favorite means of warming rooms, while the Romans had a somewhat primitive way of heating known as the "Hypocaust." The apparatus consisted of a fireplace built outside of the room, the air and smoke being conveyed through the building by means of flues perforated at intervals. In the days of the aborigines, fires were built upon the floors and the smoke was allowed to make its escape through a hole in the roof, or as best it could, for the chimney was a slow evolutionary process.

Hot Air Heating with Wood or Coal Fuel. ***Fireplaces.*** Fireplaces should be carefully planned and constructed in connection with the building of chimneys. Much care should be given to the design of fireplace flues and to the proper location of the "trimmer" and "header" beams.* Hearths should be of ample thickness and area, and no wood used to support them. Mantels should not be located so that there will be any danger of ignition. Wire guards should be provided and required in front of fireplaces to prevent sparks from flying out, or babies and animals crawling too near. Examine carefully any proposed plans for addition of fireplaces in chimneys already built and not so designed. Disused fireplaces should not be closed up with wood or paper, but with brickwork or metal, especially if any other fireplaces connected with the same flue are in use. A fall of hot soot is liable at any time to cause trouble.

Stoves. Stoves that burn wood or coal may be divided into two general classes, viz, the closed, or slow combustion stove; and the open stove. In the first kind, which may be used for either heating or cooking, the fire is fed from the top, the draft being provided from below. These stoves, as a rule, are of strong construction and do not touch the floor. The open stoves are of endless variety—some are raised on legs above the floor, while others are placed directly upon it. The danger from the two classes is pretty much the same, except that in the slow combustion stove there is not the same risk of the ashes falling out onto the floor. A prominent type of open stove is known as the "Franklin". Another prominent special type of heating stove, designed especially for wood burning, is known as the "Air-tight".

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*For a detailed discussion of the specific details of a properly constructed fireplace, the ader is referred to Fire Insurance Inspection, Part 2, pages 105 to 107. The discussion is ustrated.

Hazards of Stoves. There is but little danger from heating or cooking stoves if they are properly installed and the stovepipes suitably arranged. Although an overheated stove under such conditions should not cause direct trouble, it may, indirectly, be fraught with serious results. A roaring fire carries burning particles up the chimney to fall perhaps on a dry roof or to set fire to the chimney soot. Stoves will not explode with ordinary clean fuel. Explosions are caused by covering or banking the fire with slack coal to keep it over night. Gas and fine particles of carbon accumulate under the blanket, and the recovery of the blaze explodes the mixture. If the fire pot is filled too full, a live coal may be pushed out through a door during the night, as coal swells when it burns. In some factory buildings of large area with high ceilings, the management does not attempt to heat the entire building. Stoves are placed where most convenient for the workmen, and instances are known where workmen being removed temporarily to another section of the building have taken the stove with them, and there being no brick flue, the stovepipe was protruded through the side of the building. The use of stoves that are cracked should not be allowed.

Protection of Stoves. Stoves should always have metal legs, and be set upon a zinc, sheet-iron, or ⅛-inch asbestos covered platform extending at least 18 inches in front of the hearth and fuel doors. They should be set at least 18 inches from all wood or lath and plaster walls or partitions and the latter should be protected by metal. There should be an air space between the metal and woodwork to be protected. Protecting metal screens should be used where inflammable material is liable to come in contact with stoves. Screens of sixty-four-mesh copper wire may be used to protect stoves from dust. Stoves should always have dampers in flues. High winds may cause a hot fire which can not be controlled, and ceilings or walls, if unprotected and too near flues, may be set on fire. (See "Stovepipes".)

Proper Construction of Coal Ranges. Single coal ranges, without warming ovens below and set over wooden floors, should be mounted on a foundation of 5-inch hollow tile on metal; if two-fire or three-fire, etc., foundation should be 4-inch brick laid in cement mortar covered with 4-inch hollow tile, brick to extend 4 feet in front of range.

Coal ranges having 4-inch legs, warming oven below the baking oven, and a large ash pan under fire-box, need little attention except as to surroundings—the floor may be protected with a zinc board or sheet zinc extending 14 to 18 inches in front and 4 inches at sides and back. Where the range is set closer than 18 inches to a furred wall, the furring, wood lath, and plaster, etc., should be removed for a distance of 12 inches each side, and 6 feet above the top line of range. If there is a stud or a wood partition at the back, a wall of 3-inch hollow tile should be constructed between range and partition; tile ducts to be continuous and open top and bottom; sides, if exposed within 24 inches, to have like protection. Where a coal range is of two- or three-fire, etc., type, a foundation of 3-inch or 4-inch hard burned hollow tile should be placed on top of zinc; ducts to run the short way of range.

Hot Air Furnaces. There are numerous types of hot air furnaces designed to meet the various conditions of heating in the best manner, and with different patented innovations of more or less practical utility. The different types of heaters, however, have little influence on the fire hazard of these devices. If properly installed and carefully used, furnaces would seldom cause fires. As a matter of fact, however, they are a prolific source of trouble during sudden spells of cold weather, due to overheating.

Protection of Furnaces. Furnaces should be erected upon a solid foundation of brick or stone, with hearth of brick, stone, or cement, not less than 36 inches wide in front of the ash pit. The top or dome of the furnace, and also its smokepipe, should not be less than 24 inches from unprotected woodwork or lath and plaster, and its side walls should be at least 18 inches from combustible material. These distances may be reduced to 12 inches if the furnace is protected by 3 inches of asbestos, cement, or its equivalent. If set over combustible floors, the latter must be protected as specified for low pressure boilers.

Hot Air Ducts. Hot air ducts should be entirely of brick or hard burned terra cotta tile, properly insulated from contact with woodwork or other combustible material; but they may be constructed of expanded metal and plaster, or of bright tin, properly supported and insulated by air space of not less than 2½ inches from all exposed woodwork in either case. If constructed of tin, they must be made double with an air space of not less than one-half inch between the inner and outer flues when passing through or within wood or lath and plaster partitions; and the outer pipe to be kept 2 inches from the woodwork. Cold air ducts should be entirely of brick, metal, or other non-combustible material; but they may, under approved conditions, be of wood up to a point not closer than 5 feet from inlet base at furnace; from this distance the construction should be entirely of brick, metal, or other non-combustible material. The duct should extend to the outer side of the building wall and be provided with wire net or grating at that point.

Hot Air Registers. Hot air registers when placed in wood floors or wainscoting should be set in soapstone frames not less than 2 inches wide, well set and embedded in plaster of Paris. Register boxes, where passing through floors or wainscoting, should be of bright tin, having joist or floor timbers framed around them to leave a space of from 2 to 2½ inches on all sides according to the size of the box, the exposed woodwork to be covered with bright tin on all sides, extending from under the soapstone frame to and under the ceiling or open joist below. At least one register of any system should be kept open, either by removing the vanes or by wiring the valve open.

Stovepipes. Stovepipes passing through closets, unused rooms, blind attics, and other concealed spaces should be condemned. They should not enter chimneys at a point out of sight. Stovepipes of 6 inches or less diameter passing through floors, partitions, sides of buildings, and roofs are dangerous and should be removed. If allowed to remain, they should be protected by double metal ventilated thimbles so arranged as to maintain at least a six-inch clearance between the pipes and combustible material; thimbles to extend at least 3 inches at both ends beyond the surfaces protected. Stovepipes and smokepipes from hot-air furnaces more than 6 inches in diameter should be kept at least 12 inches from combustible partitions, walls, etc., and be protected by double metal thimbles or their equivalent. Pipes should be kept 24 inches below combustible ceilings, or else they must be protected in the same manner as boiler breechings. (See "Boilers".) Stovepipes should not enter a chimney vertically, at the bottom of a flue starting from a ceiling above, as there is danger of fire from burning soot falling out of the flue through the space around the pipe.

Hot Water Heating. The principle on which all systems of heating by the circulation of hot water depend is that of convection. As the water becomes heated by means of the boiler, it rises, and by the cold water rushing in to take its place, a current is created through the pipes which, as the hot water passes through, becomes warmer and sends its heat into the room by radiation. The various systems in use may be divided into two classes: that of the small bore, or high pressure system, and that of the large bore, or low pressure system.

High Pressure Systems. Various arrangements may be used for heating the water in the high pressure systems depending mainly on the size and the extent of the premises to be heated. The apparatus in its simplest form consists of metal tubes distributed about the premises in similar manner to ordinary heating systems, but part of the circuit is arranged in coils which are placed in an ordinary coal burning fireplace, the pipes taking the place of the usual grate bars. Where a large apparatus is necessary, the coils are arranged in an iron casing or furnace, or in a brick-built furnace. In this way the whole coil is exposed to the direct action of the flames and hot gases, the water is heated to 350°F., and the pipes are subjected to a pressure of 500 pounds and upwards to the square inch. It will be readily seen that a great heat can be obtained by this system, but it is necessary that much care should be exercised when fixing the pipes so that no woodwork or other inflammable material be allowed in immediate proximity to them. These systems are hazardous and they should not be advocated.

Low Pressure Systems. Heating by low pressure hot water systems is in general use. The usual type of sectional heater introduces no greater hazard than a hot air furnace and should be treated accordingly. These systems, as a whole, however, are considered safer than hot air systems as ordinarily installed. The hot water pipes are also less liable to cause fire than steam pipes.

Steam Heating. Boilers of the sectional type usual in domestic heating and other buildings of moderate size introduce no greater hazard than a hot air furnace and should be treated accordingly. These systems, as a whole, however, are also considered safer than hot air systems as ordinarily installed. Low pressure boilers of the tubular type, in which the steam pressure does not exceed ten pounds, are frequently used in large buildings and in factories where the boiler does not need to supply steam for power or manufacturing purposes. The rules governing the clearance between the arch or breeching (smoke flue) are the same as for hot air furnaces.

Steam Pipes. Steam pipes are known to be the cause of many fires. They should be carefully located and properly insulated, and reasonable precaution should be taken to keep them from wood. When fastened to walls at sides of room, near the floor, combustible material is apt to accumulate and fire results. The method of hanging pipes overhead at a short distance from the ceiling obviates this risk and has been shown to be scientifically correct.

Hot Steam Pipes Cause Fire. There is considerable diversity of opinion as to the circumstances under which such fires may be expected to occur and the local conditions which contribute thereto. It is evident that the hazard is materially increased where the heat is in any way confined, or where contact is with materials more flammable than wood. Particular care must be taken to guard against the presence of materials which are notably subject to spontaneous ignition, such as celluloid, coal dust, and oily waste. Investigators who have attempted to produce fires by bringing steam pipes into contact with various combustible materials, have concluded that any steam pipe, no matter how low the pressure, would in course of time produce charcoal and that when this stage was reached positive danger existed, as charcoal is subject to spontaneous ignition. Where steam is kept on a system continually, there is said to be less danger than where on intermittently. The reason advanced is that when allowed to cool the charcoal has a better opportunity to absorb oxygen than if kept hot at all times. Another factor is moisture. Experiments have shown that charcoal once wet and dried out afterwards is more dangerous than that which has remained dry, the ignition point being well below the boiling point of water.

Repeated instances have been observed in which steam has become superheated without giving any indication from the pressure gauge. This is believed to occur whenever the water is allowed to get low enough in the boiler to expose the steam to the heating surface. Superheated steam will in turn communicate its heat to the metal, and ignition may be produced whenever felt, wood, or other inflammable substance, comes in contact with any portion of the boiler or steam pipes.

General Methods of Protection. There are two general methods of keeping steam pipes free from contact with combustible material, the *first* being through the use of an insulator, such as pipe covering, and the *second* by supporting them rigidly at a safe distance. Wherever pipes pass through concealed spaces, covering should be carried for entire length to avoid future contact with substances which may get into these spaces. Care should be taken to see that any covering or lagging which may be used is composed of non-combustible material. Several brands of pseudo-asbestos and sophisticated insulating materials have been found on the market. When an insulated steam pipe passes through a partition, the lagging should pass through as well and not be cut off at each side of the partition. This point should be carefully examined.

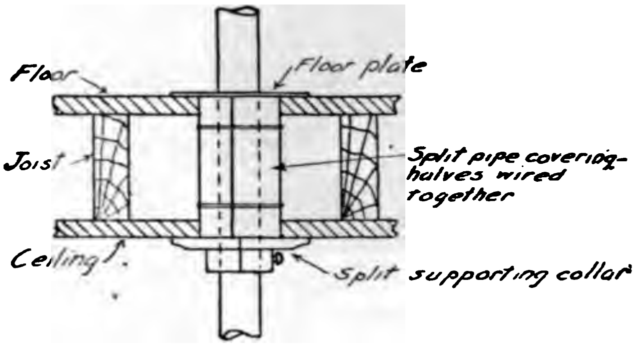

Fig. 295. Steam Pipe Passing Vertically Through Floors

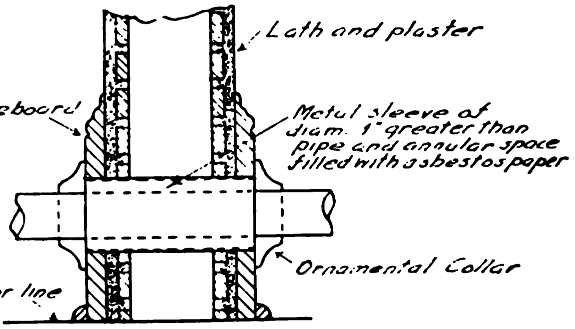
Lath and plaster
Baseboard
Metal sleeve of diam. 1" greater than pipe and annular space filled with asbestos paper
Ornamental Collar
Floor line

Fig. 296. Steam Pipe Passing Through Lath and Plaster Partition

Pipes should be bushed with metal collars where passing through floor or combustible partitions and should be securely supported.

Special Methods of Protection. The Independence Inspection Bureau, Philadelphia, have devised methods of protection which are excellent. These desirable principles, while shown in the illustrations to be applied to certain specific problems, can be adjusted to fit practically all conditions. Their description is as follows:

Fig. 295 shows pipe passing vertically through floor. Pipe covering is supported by collar below and floor plate has been used to protect end of covering and to conceal the opening. On new installations, solid covering and collars can be used; but if piping is already in place, split covering, wired together, and split collars make the partial taking down of piping unnecessary. If desired, a metal supporting plate can be used at ceiling instead of a collar.

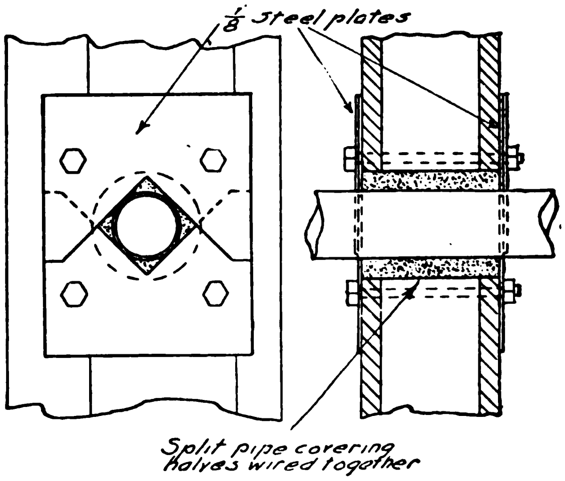

Fig. 297. Notched Plate Protection for Steam Pipe

Fig. 296 shows pipe passing through an ordinary lath and plaster partition close to the floor line. Here a sheet metal tube of diameter at least one inch greater than that of pipe is used and the annular space filled by wrapping sufficient asbestos paper around the pipe. In the horizontal position no support is likely to be needed, and the collars shown are merely for ornamental purposes. This form of sleeve could, of course, be placed vertically as well, a case in which support would be required along lines shown in Fig. 295.

Fig. 297 illustrates a notched plate which can be adjusted to a reasonable range of pipe sizes. It is, however, probably best for sizes not exceeding 3 inches. For larger pipe, hangers or brackets are recommended. Plates are used on one or both sides of a partition or floor, as the conditions may warrant. One-eighth-inch steel plates, if well supported, will stand considerable strain. Pipe covering can be placed between two pairs of plates, as shown in illustration, or carried through partition or floor from side opposite to that on which single pair of plates is located. These plates offer perhaps the best method of keeping a pipe centrally in a hole.

Fig. 298 shows pipe supported on a bar-iron bracket which will insure a certain separation from timber over which pipe passes. Not less than 1½-inch clearance is advisable. The upper portion is removable and the lower permanently secured by bolts or lag screws.

In the application of any of these methods, the following points should be borne in mind:

First, that pipe coverings are not capable of resisting appreciable mechanical strain, and that they should be called upon to act as an insulator and not as a support. With small vertical pipes, metal supports are, however, not essential.

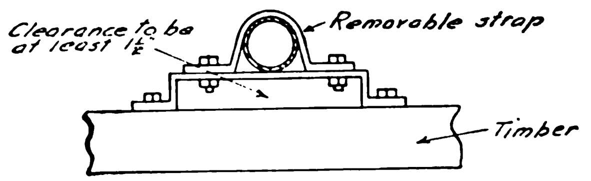

Fig. 298. Steam Pipe Supported on Bar-Iron Bracket

Second, that cutting a large hole for a steam pipe is not sufficien, as a pipe is almost certain to sag, expand, or contract, and thereb come into contact with the side of hole in which it was at one ti central.

Third, that a steam pipe should be covered wherever it is co cealed. Even if there appears to be no likelihood of any loose con bustible material getting on to pipe when same is put in place, the is always danger of accumulation of rubbish around pipes.

Combination Heating and Ventilating Systems. Combinin heating and ventilating processes depend for their successful oper tion upon a well-known principle of physics. This principle co sists in the fact that there is a difference in gravity between cold (or foul) air and heated air. The former being the heavier tends to fall, while the latter from its lightness tends to rise, these differences in density serving to create currents of opposite direction, whereby the ascending current of heated air displaces the cold or foul air, which then falls to the level of the floor of any enclosed space where from its density it would remain stratified unless displaced by agitation or by liberation through vents at its level.

Hence, in all well-designed combined heating and ventilating systems where natural forces are utilized as means of operation, the vent ducts for the escape or removal of cold or foul air are located at the floor level of an enclosure and when properly installed, insure successful accomplishment of the purpose intended, even if in arrangement and construction such systems may not always present conditions promising immunity from fire through the faults of design and installation.

The means of obtaining ventilation may be divided into the two broad classes of *natural* and *artificial.* In natural ventilation, no machinery is used to distribute the air through the rooms. Artificial ventilation is carried on by the aid of machinery or by the action of heat, or by the two in conjunction. In what is known as the "Vacuum System" a fan (or fans) draws the foul air out of the rooms, the fresh air finding its way in at various openings. In the "Plenum System," which is largely adopted, the fresh air is driven into the building by a fan (or fans) and the polluted air escapes by different apertures provided for it.

Direct and Indirect Systems. Under either one of these classes of heating and ventilation are to be found two distinct systems respectively known as the "direct" and the "indirect." Under the former the foul and dust-laden air is carried from the floor of the rooms through ducts or flues by action of the heated air currents which displace the foul, and these flues deliver the foul air above the roof of the building, thus securing the direct ventilation which serves to indicate the method, and where such system is properly installed it presents the least hazard of these combination systems. The "indirect" system seeks to secure the removal of all foul or cold air, not only from the area of the room enclosures but also from all of the hollow spaces surrounding the same, including the spaces between the floor joists and the partition studding. To accomplish this end, the area of space between the floor joists is increased by nailing two-by-four wall strips across the joists, and openings are made through partition walls from the joist-channels to the spaces between the studs, thus providing a complete maze of communicating horizontal and vertical spaces, accessible to flame while inaccessible to means of extinction, the whole presenting a method of insuring rapid combustion and destruction of the building in case of fire.

Hazards of Natural Systems. Direct and indirect systems of the natural type, when used in conjunction with furnace heating, offer the same hazards as ordinary heating systems. The foul-air ducts should be constructed in similar manner to that suggested for hot-air ducts, but they should be installed with not less than one-inch clear space at woodwork. Ducts should not be connected directly with a heating furnace nor with any hot-air or smoke-flue but preferably to a special flue adjoining a brick smoke-flue or hot-air flue carried to the same height but separated therefrom by not less than four inches of brickwork.

Foul-air flue should not discharge vertically under the roof in attic, thus providing means by which fire would very quickly reach the most inaccessible portion of the structure and gain headway before discovery. Ducts should not lead from outlets at floors above the heating device to the base of same at fire box. Falling embers from the furnace grate are liable to ignite the dust, paper, or other refuse which accumulates in the duct. Flues should not pass horizontally under the ceiling from the floor outlets above the furnace room and open into the room or smoke-flue of the heater, stack, or chimney. The heated air of the smoke-flue serves to carbonize the accumulation of dust, flyings, and other refuse adhering to inside of foul-air duct and will eventually ignite same; while a rising spark from a newly kindled fire in the furnace is very likely to cause such ignition and carry flame to the interior of the structure.

Hazards of Artificial Systems. The direct or indirect systems may be used in combination with steam heating, the steam coils being placed in a chamber through which the cold air is drawn and forced over them, the system then virtually becoming one of hot-air. Blowers are necessary, however, for this purpose and the system becomes an artificial one.

The principal hazard of this system is due to the blower or intake which may blow a fire originating at this point through the building. The blower should be kept clean, well oiled, and properly adjusted. Bearings should be outside. All blowers used to circulate air through heating or ventilating pipes in buildings such as theaters, etc., with openings to the auditorium, should be provided with a device to stop the blower automatically in case of fire. Fusible links for this purpose ought to be located near the blower both inside and outside the pipe leading to openings in the auditorium. Air should be taken from outside through an intake having a screened opening and located so as to be safe from sparks. Air should not be taken from inside, especially if there is any inherent danger of fire starting at that point. Systems arranged to circulate air by taking air from the various floors through suction pipes and delivering it back again are hazardous.

Specially Hazardous Arrangements. The Smead system, or "dry-closet" system, is a very hazardous arrangement often found in schools. This is found in use with the indirect system. In its operation the excreta from the toilets is destroyed by burning with the aid of volatile or highly combustible material such as gasoline or kerosene oil for fuel.

There is another class of heating and ventilating system for use in country schools of the one-, two-, and three-room variety. This class has several representatives all similar in construction and principle, known as the Waterbury Heating and Ventilating System, the Paragon Heating and Ventilating System, and the Moore System. These should be condemned wherever found. They are composed of an extra large stove (nearly as large as an ordinary domestic hot-air furnace) around which is set an upright galvanized-iron jacket about 3½ feet in diameter by 5½ feet high, open at the top. The jacket consists of two pieces of iron interlined with asbestos board and stands about 3 inches from the floor.

A horizontal fresh-air intake pipe, twelve by sixteen inches, passes through the side wall, opening outside, and enters the jacket at one side. Thus, the cold air on entering forces the hot air which is inside the jacket out at the top and it circulates about the room. Bolted to another side of the jacket is a vertical twelve-inch outlet pipe or ventilating flue open at the bottom and within six inches of the floor. This flue passes through the ceiling, blind attic, and roof. The heat against the inside of this flue generates a draft which is supposed to take the vitiated air from the room to the outside of the building. The jacket has two duties to perform. It is supposed to protect adjacent woodwork from the heat of the stove and to protect pupils from direct rays of heat. The other duty is to concentrate the heat so that it may be forced out at the top and thence circulate about the room.

As a matter of fact, the heat is not equally distributed about the room. It is forced out at the top directly against the ceiling with sufficient force to blister the paint and discolor the woodwork. It is necessary to keep up a very hot fire in order to keep the entire room well heated. The jacket hides the stove from view and when the stove gets red hot it is not noticed. These heaters appear to be equally unsatisfactory from the utility point of view. School teachers state that the rooms are not equally heated, that the pupils are warm from the waist up and cold from the waist down; that those sitting nearest to the heater continually complain that their backs are hot and their feet cold. These systems have been the cause of several fires.

Gas Stoves. Gas stoves may be divided into three classes, viz, plate, or single burner; ordinary house stove; and gas ranges.

Plate or Single Burner. These are ordinarily found in tailor shops and under coffee urns, etc. A foundation of 3-inch hollow tile should be used except where burner is needed for heating small irons. Zinc should then be placed on top of board foundation and sheet-iron plate suspended directly under burner midway between top of stove and table or support; or further, the table may be cut away directly under the burners.

Ordinary House Stove. This type is sometimes used in small restaurants and is usually set on a perforated base or on 2-inch legs. This class of stove, if in a dwelling, needs only zinc under it; but if in a restaurant, it should be protected with a foundation of 3-inch or 4-inch hard burned hollow tile; clearance at sides and back to be the same as for coal stoves.

Gas Ranges. This type is usually found in large restaurants and hotels. The foundation generally required for this class is a sheet of metal, not less than No. 16 U. S. gauge, over spacer of range and extending 4 feet in front and 12 inches at sides of same (edges

TYPICAL EXAMPLE OF FIRE-FIGHTING EQUIPMENT IN ACTION

may or may not be turned up 2 inches to form a pan); on top of the metal a foundation of 4-inch brick laid on edge and pointed up with cement and mortar. This brick foundation must extend from the wall to 4 feet in front and 12 inches at sides of range; on top of brick and under range only, a foundation of 4-inch hard burned fire-tile ducts should extend the short way of range. Clearance from partition and combustible material must be the same as for coal stoves.

Gas Hot-Water Heaters. Fires in dwellings have been traced to defectively installed hot-water heaters. The exhaust flue has been allowed to terminate in the attic without carrying it through the roof. This is done in order to avoid cutting the roof both because of the expense and to avoid any objections of the owner of the building. In many cases the exhaust pipe has ended close to the roof and in case of explosion of gas the flames would strike the roof, while in many cases the continued heat has carbonized the woodwork so that it was more readily set on fire. If the vent pipe is not carried through the roof, an elbow should be placed on the end so as to direct the hot air and gas away from direct contact with the roof. A better way is to connect it with the chimney if it is desired to avoid cutting the roof.

Relative Hazards. The elements entering into relative danger of gas stoves are as follows: Construction, method of connection with gas supply pipes, pressure and nature of the gas used, surroundings of the stoves, protection of surrounding inflammable materials, and method of carrying off waste or unburned gases. The most dangerous hazard is the use of soft rubber tubing connection between the stove and the supply pipe. Only rigid iron gas pipe connections should be allowed. Gas stoves should be mounted as previously described. Inflammable surroundings should be properly protected by metal or asbestos. Enclosed heating stoves should all be provided with as good flues as are used for coal stoves; and open gas stoves, such as hot plates or gas crowns, should have ventilated metal hoods to carry off any escaping gas. Fires in stoves burning natural gas sometimes go entirely out under low pressure and unless the stove valves are shut off, the increase in pressure would quickly fill a room with gas, possibly causing an explosion.

Gas Irons. Besides the hazards in connection with the use of gas as described under Stoves that apply to this device, there is the danger that an iron will be left on combustible material while the heat is on.

Kerosene Oil Stoves. The small portable one- and two-burner kerosene oil stoves that are in such common use have practically the same hazards as kerosene oil lamps, and the rules and suggestions given under the latter heading will apply to these devices. Stoves are never made of glass. They do, however, smoke readily if not properly adjusted. The larger stoves of the so-called "blue flame" type are probably safer than the small devices, in that they have not the hazard of portability and they do not necessitate the use of a wick at the burners. The size and location of the storage tank are important, however, and the same rules should govern the protection against surrounding woodwork and inflammable material as are given for coal or gas stoves.

Kerosene Oil Pressure Stoves. These systems used to supply kerosene vapor stoves, blow-torches, and furnaces with oil under considerable pressure are regarded from an insurance viewpoint as much more hazardous than ordinary kerosene stoves. Where used the rules and requirements which have been prescribed in connection with kerosene vapor lamp systems should be rigidly observed, and the remarks under that heading apply here.

Special Features. Special features which apply to kerosene oil pressure stoves, water heaters, or open burners, are as follows: They must be supported on a substantial frame or stand relieving the piping from all unnecessary strain. Proper protection must be provided to prevent overheating or ignition of adjacent materials. Enclosed stoves must be provided with a suitable chimney connection. They must have a readily accessible shut-off and regulating valve and must be provided with a metal pan made tight without solder and placed beneath the burner.

Blow-Torches and Furnaces. Blow or plumbers' torches must have all parts accessible for purposes of cleaning or repairing. The burner must properly generate under any condition of working pressure or regulation. Cleaning or needle valves must have steel stems with a shoulder which will act as a stop and prevent the enlarging of the gas tip. Furnaces must be provided with a shut-off valve between the tank and the burner, closing against the pressure in a positive manner.

The careless use of these torches causes many fires. This hazard can not be overcome by proper construction.

Alcohol Cooking Stoves, Etc. As with the use of alcohol lamps, the use of alcohol stoves assumes the use of denatured alcohol. The use of wood alcohol should not be allowed for this purpose. Alcohol stoves are being used in constantly increasing numbers and their hazards should be thoroughly understood, as well as certain fallacies and prejudices against these devices. Many of the explosions credited to these devices have been due to the accidental or unintentional use of gasoline.

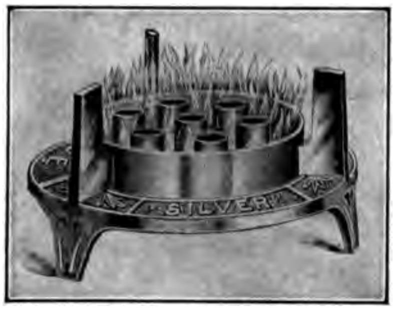

Fig. 299. Alcohol Stove—Class 1

Types of Alcohol Stoves. There are four types of alcohol stoves in general use today. The principle of their operation consists in the fact that they vaporize the alcohol and then burn it in the form of gas. This necessitates the use of a small amount of alcohol which must be ignited in order to heat the burner sufficiently so that when alcohol is allowed to flow through it, the alcohol is turned into gas. This gas in escaping through the jets in the burner mixes itself with about one-quarter of its own volume of air, and a hot blue flame results.

Class 1. Stoves of the *open pan type* with air vent tubes which pass through the pan from the bottom to a point above the level of the liquid in the pan, making a central draft burner. The alcohol burns freely on the surface of the liquid. Perfect combustion and intense heat are obtained by the air being drawn up through the tubes and mixed with vaporized alcohol while burning. A cover is provided which closes up the required number of vent holes to lessen the intensity of the heat. This type is illustrated by Fig. 299.

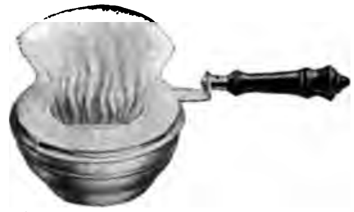

Fig. 300. Alcohol Stove—Class 2

Class 2. Stoves of the *asbestos-filled class.* These operate by the absorption of alcohol in the asbestos in the burners. Such stoves or lamps are used to a large extent for chafing dishes, heating curling irons, etc., and are the most common type of alcohol device on the market at the present time. This type is illustrated by Fig. 300.

Class 3. Stoves of the *capillary wick class.* These have a fount under the burner with a wick from the burner into the reservoir. The alcohol is raised by capillary attraction and burns freely after once started. This type of lamp must have a pump or priming device to start the action. Vent tubes pass from the fount up to the burner through which vapor arising from the alcohol may pass and be consumed at the burner. This type is illustrated by Fig. 301.

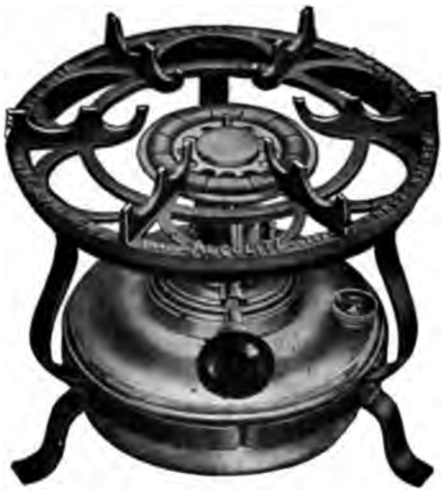

Fig. 301. Alcohol Stove—Class 3

Class 4. Stoves of the *gravity feed type.* This class is the type of the larger stoves most commonly found in use today. The alcohol is stored in a reservoir above the burner and flows by gravity to the burner. These stoves necessitate the use of a priming pan about the burner to insure sufficient heat to vaporize the alcohol into gas as it issues through the burner. Flatirons are also an adaptation of this type. In order to start the flatiron, the burner, a round perforated tube attached to the reservoir, is removed and placed in a small special priming pan in which sufficient alcohol is burned to start the proper action of the burner. As the cost of denatured alcohol decreases, these irons will probably find extended use. They do excellent work without giving any discomfort because they do not radiate heat as does an ordinary iron, and an even heat can be continuously maintained. This type of stove is illustrated by Fig. 302, and a typical flatiron by Fig. 303.

Hazards. Class 1. This type of burner so far as efficiency of operation is concerned is really the best, but there is ever present the very real danger of being upset. The presence of a pan of burning alcohol makes this a serious hazard. They should be firmly fastened to a table where used with a shallow tray underneath.

Class 2. These devices as commonly found are perhaps the safest form of heating with volatile liquid fuel in common use today. Owing to their extreme simplicity, however, there is a tendency to make them too cheap. Care should be taken to select a type, from well-known manufacturers, that does not leak. This type should not be made too large and if so made, should be avoided.

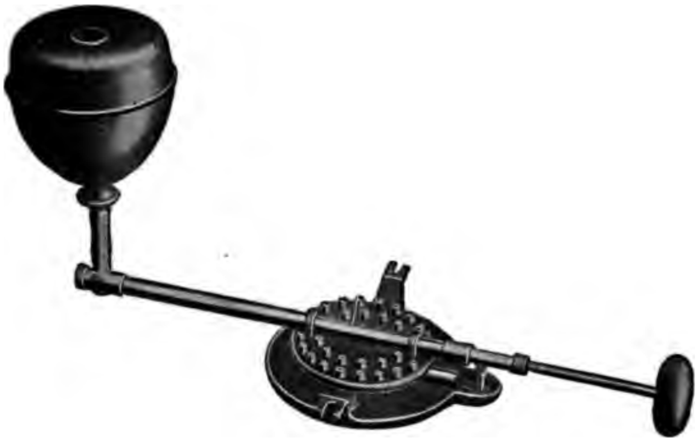

Fig. 302. Alcohol Stove—Class 4

Class 3. It is essential in this type of stoves that wire gauze be placed in the air-vent tubes. Fire has been known to communicate with the alcohol in the fount through these vent tubes and also through the pump, when explosions are thus made possible. The safety of these devices lies in proper design, and there are such stoves on the market. The air vents are small with wire gauze carefully inserted; the pumps are especially designed so that they are tight under normal conditions; and the free space between casing and plunger is too slight to admit the communication of fire from the burner to the contents of the fount. This type of construction makes the overflowing of the fuel, due to accidental opening of the regulating valve, impossible.

Fig. 303.
Alcohol Flatiron—Class 4

Class 4. If the alcohol reservoir becomes empty and a flame is communicated to the vapor within, an explosion is possible. This is not a probable condition. If such an explosion occurred, it is not likely that a fire would result. Also if the vent or filling hole is of proper size, it would relieve any sudden pressure and there would be no rupture of the reservoir.

There is an overflow hazard in connection with the use of these stoves. If the priming pan is carelessly filled or the regulating valve is accidentally opened or tardily closed, the pan may be overflowed. The alcohol runs down onto the table and perhaps saturates a portion of the table cloth. The alcohol in the priming pan is ignited. Under the influence of the heat, the contents expand and overflow. The flame will soon creep along the trail of hot alcohol and in a moment the saturated table cloth or soaked table is all ablaze. Owing to this hazard it is suggested that a shallow tray be provided to protect the surface of the table or other stand which supports this stove.

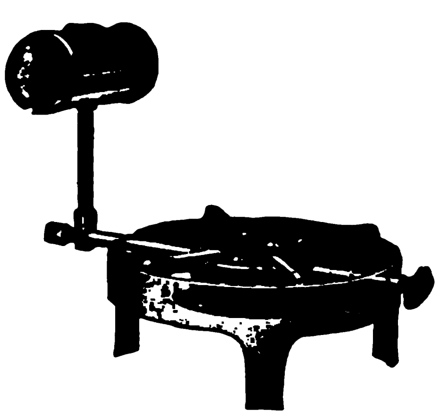

Fig. 304. Alcohol Stove—Class 4.
Note Small Priming Pan and Large Burner

The stove shown in Fig. 304 illustrates a hazard which may be introduced by an improper design. The priming pan is so small that it is necessary almost completely to fill it in order to secure sufficient heat to start the proper action of the burner. Twenty-five drops more than the necessary amount will overflow the pan. The burner is also too large, in relation to the number and size of jets, for sustaining the proper degree of heat to insure constant vaporization. Liquid alcohol is thrown out which causes a puff of flame to shoot up. Although this will heat the burner and proper action ensue for a while, as soon as it cools down again, another puff of flame will result. This condition, both annoying and dangerous, is due to the poor design.

General Hazard. All of these devices possess the hazard incident to their being filled while burning. Under no circumstances should any one of them be filled while in operation. Most of the accidents from the use of stoves of Class 2 have been due to this cause. Users frequently attempt to fill the Class 1 burners while in use. Such a procedure naturally invites a fire or disaster. Many manufacturers sell a special device for filling the stoves while burning. None of these should be countenanced and insurance companies should exact a pledge, with forfeiture of indemnity if violated, that no alcohol stoves shall be filled while the same are lighted and in use. With this hazard practically eliminated and stoves of reputable makers in use, there need be very little apprehension of trouble from the use of denatured alcohol burning utilities.

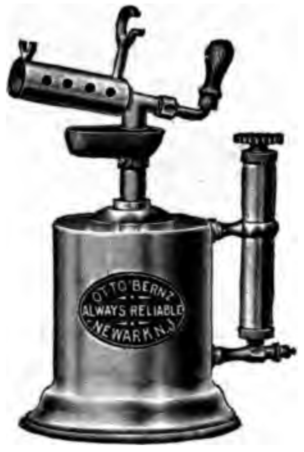

Fig. 305. Gasoline Blow Torch

Gasoline Cooking and Heating Stoves. The use of gasoline as fuel for domestic purposes is regarded from an insurance viewpoint as much more hazardous than the use of ordinary fuel, such as coal, wood, gas, and coke; and where used the hazard should be recognized by underwriters in higher rates of premium. If permitted, the specifications for construction of such devices and for regulating the same must be observed in order to secure the largest measure of safety to life and property. Only approved apparatus should be allowed.

Protection. A few general requirements follow, the details of construction being fully covered in the Rules and Requirements covering this class of device.

Stoves must always rest on the floor or a permanent foundation and never on boxes, shelves, or temporary supports; they must not be placed in proximity to wooden shelves, cupboards, or other inflammable material.

Stoves must be of sufficient height to bring the main burner grates at least 24 inches above the floor or support.

Reservoir must not exceed one gallon capacity.

Cover of tank must be constructed so that it can not conveniently be used as a receptacle for matches or cooking utensils.

The generator must be initially heated by a smokeless torch or a burner attachment which will obviate the use or necessity of an open gasoline drip cup.

Fire Pots, Braziers, and Torches. Only such devices as have been approved and listed should be allowed. Even this will not remove the ever present hazard of the plumber's torch, such as shown in Fig. 305, which is due to careless handling; the presence of the powerful open flame can not be avoided.

Fire pots and torches must be so arranged that not over one gallon of gasoline may be supplied to the former and not over one quart of gasoline to the latter. The generators must be initially heated by a smokeless torch or a burner attachment which will obviate the use or necessity of an open gasoline drip cup. Explicit directions for their construction are given in the Rules and Requirements, which are observed in the devices listed by the Underwriters' Laboratories.

Electric Heating and Cooking. Heating by means of electricity, with the exception of electric cars, is a comparatively new development, but undoubtedly it is destined to be used to a greater extent, as cheaper and easier means of converting electric energy into useful heat are discovered. The recent great development in the cheap production of electric current has given impetus to this line of endeavor, and cooking stoves and ranges are now finding a practical field of use. The small utilities, such as curling irons and flat irons, foot warmers, water heaters, plate warmers, toasters and grids, chafing dishes, egg cookers, and other dining table novelties, have already become well established in use, and certain hazards incident to their use are causing many fires.

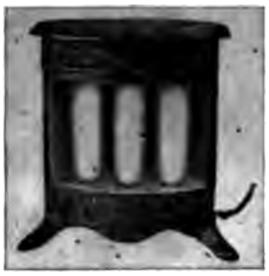

Fig. 306. Electric Heater

Methods of Heating. The simplest method consists of open resistance wires which carry the current, and act as the heating element. Toasters and grids and electric car heating radiators are typical examples. In the systems in most general use at the present time a series of resistance coils is embedded in a special enamel to protect the wires, the whole being enclosed in suitable metal cases. Certain types of heating radiators and most of the ranges, stoves, and small household utilities are made on this principle. In another class of heaters which have been adopted for use as room heaters and ranges, the heating element consists of a system of incandescent lamps of considerable size and special shapes arranged in a suitable screen or frame, which radiate the heat. In these lamps the vacuum is imperfect, and the oxygen left in the tubes gives the required heat. An electric heater is shown in Fig. 306 and a cooking stove in Fig. 307.

Hazards. The usual precautions should be taken with all types of apparatus that are taken with other heat-giving elements, as well as the usual precautions with regard to electric wiring. The principal danger consists in the promiscuous use of the devices that can readily take current from light sockets with the consequent danger of overloading the circuits. The other great source of danger arises from carelessness in leaving the irons and other apparatus about on inflammable material with the current on.

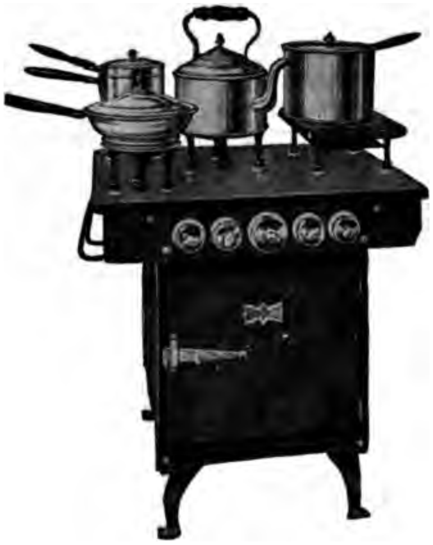

Fig. 307. Electric Cook Stove

Electric Irons. Perhaps the greatest hazard today is that offered by the use of the electric iron such as shown by Fig. 308. The convenience of this device has made it very popular and its use is daily becoming more general not only in the homes, but in laundries, tailor shops, and cleaning and dyeing establishments. Fires are constantly reported as being caused by these irons overheating, resulting from the failure of the operator to detach them or turn off the current.

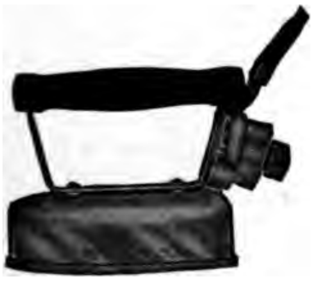

Fig 308. Electric Flatiron

The National Board has designed an installation for electric irons, which consists of a small one-candle power red light to be placed in the connection below the lamp socket; the idea is that the burning of this red light will suggest the detaching of the connection or the turning off of the current in case the iron should be laid aside.

Chimneys and Flues.* The South Eastern Underwriters Association has promulgated the following excellent suggestions for the standard construction of chimneys and flues:

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*The National Fire Protection Association has just issued a most exhaustive specia Bulletin on this subject.

All main chimneys for fireplaces or furnaces should be well and securely built from the ground up and through the building to a point at least 3 feet above flat roof and 2 feet above ridge of peak roof of such building; the walls of chimneys should be of stone or brick at least 8 inches in thickness (if fireplace is of stone same must be 12 inches); and beginning with foundation such brickwork or stonework should be laid in cement mortar up to the first floor; but thence above to a point where chimney protrudes through the roof of building, the brickwork or stonework may be laid in good lime or fire-clay mortar, and brickwork carefully bonded or anchored together. From and above the roof to top of chimney the brickwork or stonework shall be laid in cement mortar and properly capped. All joints to be struck smooth on inside except when lined with burnt clay or terra cotta pipe.

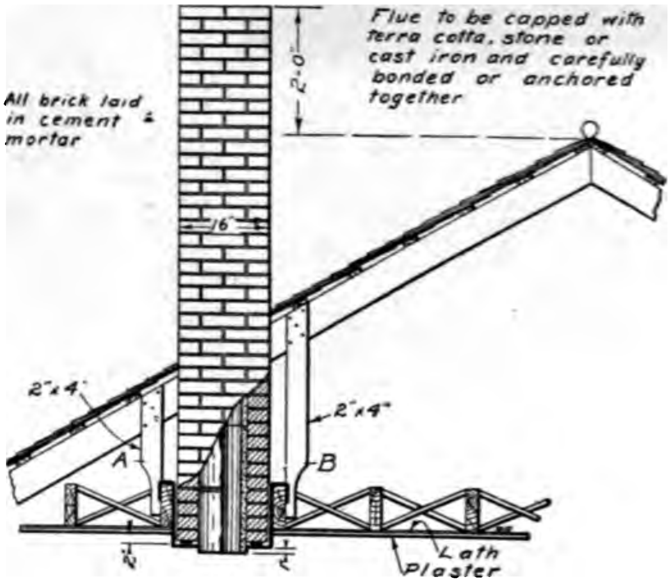
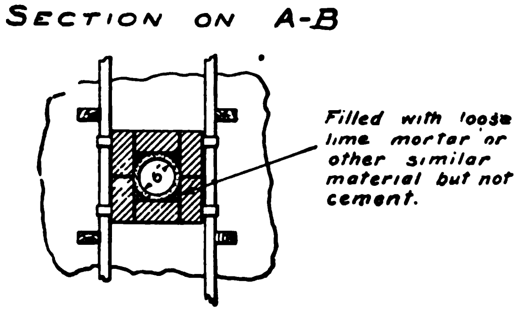

Flue to be capped with terra cotta, stone or cast iron and carefully bonded or anchored together
2'-0"
All brick laid in cement & mortar
16"
2"x4"
2"x4"
A
B
Lath
Plaster

Fig. 309. View of Stove Flue

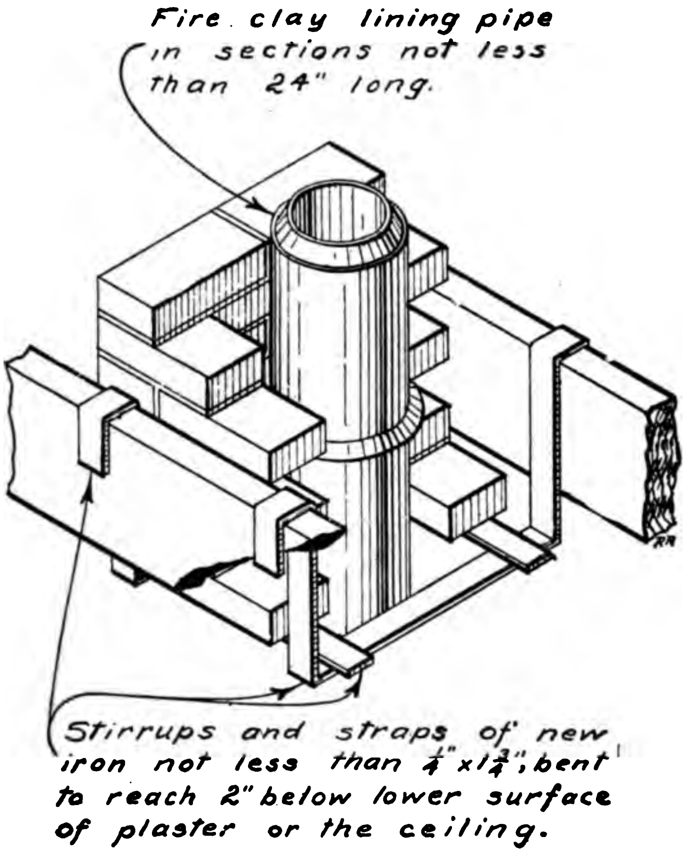
In brick buildings, the walls, when not less than 13 inches in thickness, may form part of chimney or flue. In no case shall a chimney or flue be corbeled out more than 8 inches from the wall and in all cases the corbeling shall consist of at least five courses of brick. Flues in party walls must not extend beyond the center of said walls.

When two or more separate flues are provided in a chimney, the division walls between flues are to be only 4 inches in thickness. No chimney should be started or built upon any floor or beam of wood. When a chimney or flue is to be cut off below, in whole or in part, it must be wholly supported by brick work or stonework properly erected from the ground up. Single chimneys or flues for stoves or kitchen ranges may have the walls only 4 inches in thickness. The upper part of chimney or flue walls may be only 4 inches in thick-



Filled with loose lime morter or other similar material but not cement.

Fig. 310. Section of Stove Flue



Fire clay lining pipe in sections not less than 24" long.

Stirrups and straps of new iron not less than $\frac{1}{4}$" x $1\frac{3}{4}$", bent to reach 2" below lower surface of plaster or the ceiling.

Fig. 311. Details of Hanging Stove Flue

ness, from a point at least 6 inches above the roof covering of building to the top of chimney or flue, provided the chimney or flue be capped with terra cotta, stone, or cast iron, or carefully bonded or anchored together.

No wood casing, furring, or lath or other woodwork shall be placed in, against, or within 2 inches of chimney or flue. All wood beams shall be trimmed away from all flues and chimneys at least 2 inches. (See under "Fireplaces" for further reference to illustrated discussion of their proper construction.) Tile chimneys and the use of sewer pipe should not be allowed. Chimneys should be lined with fire clay brick or fire clay tiling which are especially constructed to withstand heat, sulphurous acid, and changes in temperature. These cost less and are more efficient.

Stove Flues. In certain sections of the country where the climate is mild, the custom prevails of using no chimneys or of using chimneys built from the ceiling up to accommodate the smoke flues. Where such a condition prevails, flues should be constructed in a manner similar to that proposed by the South Eastern Underwriters Association, which is as follows:

Stove flues shall be constructed of hard burned brick laid flat in cement mortar and shall be not less than 16 inches square from base to top, lined with fire-clay piping in sections not less than 24 inches long. Flue to be hung on iron stirrups of new iron of not less than ¼ by 1¾ inches, bent to come at least 2 inches below surface of ceiling or on other approved metal supports conforming with these requirements. No flue is to be less than 3 feet above flat roof and 2 feet above ridge of peak roof.

A view of such an arrangement is shown in Fig. 309, a plan in Fig. 310, and special detail of the arrangements for hanging, and the lining in Fig. 311.

POWER AND TRANSMISSION

The generating equipment for power, whether by steam, electric, or internal combustion engine, should be located preferably in a detached power house of substantial brick construction or in a fireproof room properly cut off from main building. It is essential to understand the various types of power units and the nature of their hazards so that they may conform to certain rules made for their construction and safe installation. The greatest number of fires attributable to power is due, however, to the hazards of friction and transmission and they will be considered under separate heads.

Water. Although wheel pits are more or less damp and wet at all times, fires are apt to originate there. The heavy bearings, if neglected, heat up and ignite the surplus gummed grease that accumulates. Lint and other inflammable material often accumulate in this place. Such places should always be protected by automatic sprinklers. Tailraces should also receive thought and care. Burning material, such as kerosene, may float into them upon the surface of the water. The fore-bay should be planked above the highest rise of water, and the water wheel securely blocked when the mill is stopped at night or on holidays, to prevent freshets from running the mill while unattended and causing fire from friction. Water wheels should be located preferably outside of main factory, but may be located inside a factory of standard mill construction.

Steam. Few fires have originated within, or directly due to presence of, a steam engine. One or two fires have been recorded due to the combustion of the wood lagging from long contact with the cylinder of the engine. The low basements which prevail under an engine room floor and in the pits around the engine or fly wheel are likely to be the breeding spots of fire due to the collection of oil, oily waste, and other combustible material. In a building of standard mill construction, the engine must be located in a one-story cutoff section. Steam mains from boiler to engine should be well protected by insulating lagging. As these mains carry steam at high pressure, and perhaps superheated, great care should be taken to protect pipes if they pass through or near any combustible material.

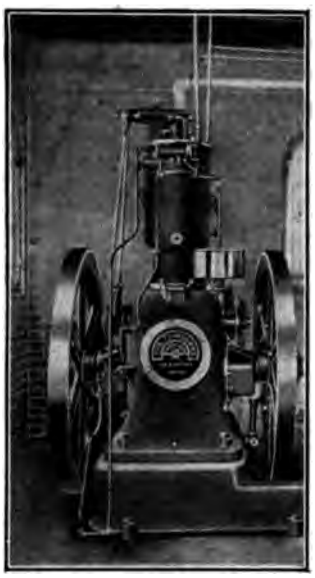


Fig. 312. Gas or Gasoline Engine

Gas Engines. Only approved engines should be allowed and they should be installed according to the rules which have been made. Engines should, if possible be located on the ground floor, Fig. 312, and in rooms where inflammable flyings prevail, the engine should be enclosed in a well ventilated compartment. If located on a wood floor, the floor under and 24 inches outside of the engine must be covered with metal. Piping should be provided with a shut-off valve located in an accessible place on the service side of the pressure regulator, and the piping and connections must run as direct as possible and be thoroughly tested before being placed in service.

Protection of Hazards. The principal hazard consists in the muffler, or exhaust pot, and the exhaust pipe. These are liable to become very hot. Muffler, or exhaust pot, should be placed on a firm foundation and kept at least one foot from woodwork or combustible materials; it must be covered with approved non-combustible insulating material of a thickness proportionate to the size of the device, in no case to be less than three-quarters of an inch. Exhaust pipes should extend to the outside of the building and be kept properly supported, at least 6 inches from any woodwork or combustible material; and if run through floors or partitions they are to be provided with ventilated thimbles at least 6 inches larger in diameter than the pipe; and the vertical portion of a pipe that passes through a floor must be covered with approved non-combustible insulating material. In no case should they discharge into a chimney. As these pipes are liable to become very hot they should have additional protection where dust or inflammable flyings are present.

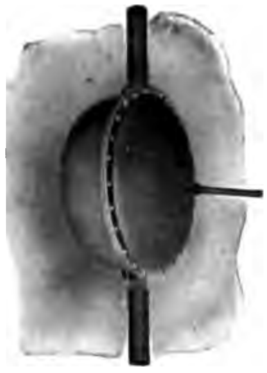


Fig. 313. Gas Engine Pressure Regulator

Gas Regulator. A gas regulator is an apparatus designed (1) to equalize the gas pressure between the meter and engine (the source of supply and the gas engine), regardless of the variations in pressure in the gas system; and (2) automatically to shut off the supply when the engine stops. Gas bags, if used, must be enclosed in a substantial gas-tight metal drum of approved construction vented to the outer air through a pipe use for no other purpose Such an arrangement is shown in Fig. 313.

Only an approved pressure regulator should be allowed. Suc a device consists mainly of three parts, viz, a cast-iron enclosure con sisting of two castings bolted together, a leather diaphragm hel between these two castings, and a valve which controls the admi sion of gas to the upper part of the enclosure and thence to the engin The controlling valve rises only when the engine takes the inductic charge or when raised by hand by means of an eccentric which employed when starting the engine. The diaphragm is made of sk and separates the interior portion of the two castings into an upper and a lower chamber. A suction of gas at the engine produces a partial vacuum in the upper portion of the equalizer and thus causes it to rise at the center. This raising of the diaphragm transmits its motion to the valve which is consequently raised, thus allowing the admission of gas. With all parts assembled, there is no possibility of gas escaping into the room, as there is a vent which is piped to the outside and this vent pipe is provided with a valve to detect any possible leakage of gas past the diaphragm.

Where not otherwise provided for, the regulator should be arranged with an automatic gas shut-off to prevent the flow of gas into the room in case engine shuts down from any cause.

Gasoline Engines. Only approved engines should be permitted and they should be located in a manner similar to that of gas engines. Supply tank must be located outside the building, underground, where possible, at least 30 feet, but never less than 5 feet, removed from all buildings and below the level of the lowest pipe in the building used in connection with the apparatus. If impracticable to bury the supply tank, the same may be installed in a non-combustible building or vault, properly ventilated, preferably from the bottom, always remembering that the tank must be below the level of the lowest pipe in the building used in connection with the apparatus. Auxiliary inside supply tanks should not be used. The engine base should not be used for storage of gasoline or any other material. Specific rules govern the installation of piping, which should always be observed. Muffler or exhaust port and exhaust pipe must be treated as for gas engine, and the same rules apply as to care and attendance.

Portable Gasoline Engines. In this class are included so-called "self-contained" engines, mounted on wheels, or on skids, or otherwise so arranged as to be conveniently moved from place to place as the necessities of the service may demand. These engines are regarded from an insurance viewpoint as more hazardous than stationary engines having separate underground storage tanks, and should not be used as a substitute for stationary engines. Where used, their hazards should be recognized by Underwriters having jurisdiction, and the rules and precautions rigidly observed.

Fuel Oil Engines. These are substantially constructed, internal combustion engines designed to operate on crude oil, distillates, or kerosene. They utilize the heat of combustion and compression retained in the walls of a special vaporizing chamber for igniting the charge. Initial heating is accomplished by a stationary gas or kerosene blow torch. The same rules for installation, etc., apply as for gasoline engines. Crude oil possesses characteristics similar to those of gasoline, and its storage and use should be governed by the rules and requirements for fuel oil systems.

Producer Gas Systems. In the most familiar process of gas making, the manufacture of coal gas, the coal is subjected to destructive distillation. The resulting gas is high in illuminating qualities and has a relatively high heat value. In this process a valuable by-product is coke. In another process of making gas from coal a moderate supply of air, with or without vapor or steam, is passed through a thick fuel bed. By the proper regulation of this air supply, a partial or incomplete combustion of the fuel is maintained, resulting in the gradual consumption of all the combustible matter. The coke instead of remaining as a by-product, as in the process previously mentioned, is utilized in making the gas. Gas generated by this method is known as producer gas, and the apparatus in which the gas is made is called the gas producer.

As it is probable that the producer gas system of power generation will find a rapidly increasing use in this country, it seems desirable to consider in detail the types of systems and the principle and method of their operation, so that their characteristics and hazards may be well understood.

Types. Three distinct types of these plants have been commercially manufactured in the United States: (1) the suction type; (2) the pressure type; and (3) the down-draft type. Besides these three, a combination of the principles of up-draft and down-draft has recently been brought forward in the double-zone producer. Probably 75 to 80 per cent of the demand for power is for units below 300 h.p. For such, where suitable fuel is available, the suction plant is primarily designed. It costs less, occupies less space, requires less labor, and has perhaps a little higher efficiency in daily service, especially if the pressure plant has an independent boiler. By combination of units any desired horsepower can be attained. They may also be modified to deliver gas under pressure, an expedient especially serviceable where gas is desired for heating and power.

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ASTOR, LENOX AND
TILDEN FOUNDATIONS.

HIGH PRESSURE SYSTEM IN ACTION ON WINTER FIRE

Suction Producer Plants. The essential parts of a suction producer plant are the gas generator, or furnace; the steam generator, or boiler; and the gas cleaner, or scrubber. A fire is made with shavings, wood, etc., on the grate *a*, Fig. 314, of the gas generator, the air necessary for combustion being supplied by means of the blower at *i*. As soon as the fire is sufficiently kindled, the fuel to be used for gas making—charcoal, coke, or anthracite—is gradually charged into the producer. The blower for the air supply is driven by hand, or in large plants by electric or other power, until gas of sufficiently good quality to operate the engine is generated. The quality of the gas is roughly ascertained by means of a test cock at which the gas is lighted. As soon as the test flame shows the right color, which can be readily determined after a little experience, the gas is turned into the engine. The smoke and poor gas developed during the early stages of combustion are discharged into the outside air by means of the purge pipe shown at *c*. As soon as the engine is started, the blowing of the producer is stopped and the necessary combustion is drawn into the base of the producer by means of the engine cylinder. At *b* is shown the steam generator or boiler for this particular type of producer. Steam at atmospheric pressure is generated by the heated gas which leaves the producer at the point *d* and enters the boiler through the pipe *e* on its way to the scrubber. The steam thus generated is picked up by the air supply passing into the base of the producer. The mixture of air and steam is then drawn up through the incandescent fuel bed. The

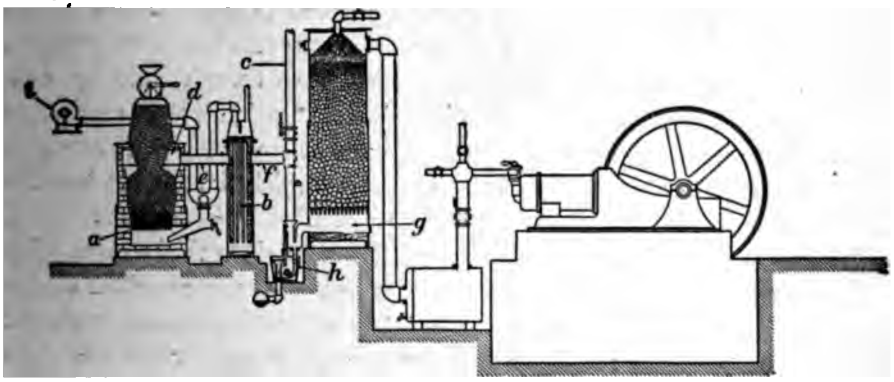

Fig. 314. Diagram of Producer Gas System

oxygen of the air and the oxygen of the steam combine with the highly heated carbon in the lower part of the bed, producing complete combustion and developing carbon dioxide. The gas thus formed passes up through a thick fuel bed above and the carbon dioxide is largely reduced to carbon monoxide. The hydrogen liberated by the decomposition of the steam greatly enriches the product.

Purifying the Gas. The gas after leaving the boiler at the point *f* passes to the base of the scrubber *g*. The scrubber is usually a cast-iron or sheet-steel tower in which the dust, soot, tar, and other impurities are removed from the gas. As usually constructed, it consists of a simple cylindrical shell filled with coke, over which water is sprayed. The dirty hot gas enters the base of the scrubber and flows upward; it is divided in passing through the coke into separate streams which are met by a fine water spray flowing in the opposite direction. The gas and the water are thus brought into intimate contact, and the particles of dirt and other foreign matter carried by the gas are largely washed out. The wash water from the scrubber passes into a water seal shown at *h*, from which it overflows into the drain, or, in large installations, into a settling basin or reservoir. If the gas is to be used in an engine it is essential that it be thoroughly freed from gritty material in order to prevent scouring of the engine cylinders. It is equally important that tarry compounds be removed in order to prevent clogging of the engine valves and governor. The gas enters the scrubber at a relatively high temperature (500° to 1000° F.) and leaves it at about atmospheric temperature, going to the engine as a comparatively dry, clean, cool gas.

Dry Scrubbing. In some plants after the gas leaves the wet scrubber it is passed through a dry scrubber. This consists of a chamber filled with excelsior, shavings, or other similar material which removes a large portion of the moisture and also tends to take out any of the impurities which may have escaped the water spray. Just before passing to the engine, the gas is usually carried through some form of expansion chamber or regulating tank which serves to prevent serious fluctuations in the draft through the fuel bed and also tends to supply the engine uniformly with gas.

Action of the Engine. The gas together with enough air t form an explosive mixture with it is drawn into the engine cylinde during the suction stroke. One of the advantages of the suctio type of producer is that the supply of air and steam passing through the fuel bed, and consequently the quantity of gas generated, is largely regulated by the demands of the engine. The designers of plants endeavor to procure simple, automatic devices to produce this important theoretical condition in regular operation, and some of the plants on the market are very satisfactory in this respect.

Fuels. Fuels containing a large percentage of tar are not suitable for use in the suction producer; hence, the fuels regularly used in such plants are charcoal, coke, and anthracite. Gas producers are ordinarily charged with coal by filling some form of hopper either by hand or from an overhead chute. By releasing the "bell" or conical casting closing its lower opening, the charge falls and is fairly spread in the producer. The attendant, using a spreading bar inserted through the poker holes in the top plate, completes its distribution. The Bildt automatic feed continuously delivers the coal in a shower from the deflecting surfaces of a constantly rotating distributer. It has a storage magazine which requires filling at longer intervals than in ordinary charging. Such a feed is shown in Figs. 315 and 316.

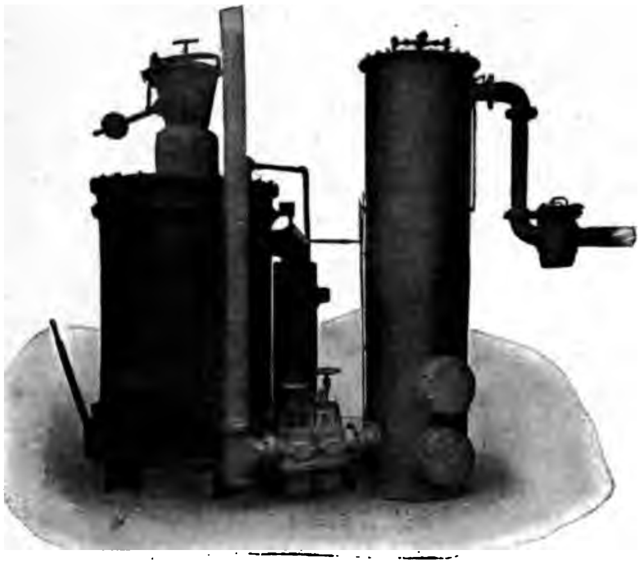

Fig. 315. View of Gas Producer

Pressure Producer Plants. Like the suction producer plant, the up-draft plant has the following essential parts: a gas producer, or generator; a steam generator, or boiler; and a gas cleaner, or scrubber. Pressure producers were devised to meet the demand for the concentration of power in fairly large units instead of the separate operation of a large number of installations of small power capacity. These producers develop their gas under a slight pressure due to the introduction of the air and steam blasts, and the gas is stored in holders until required by the engine. As the generation of the gas does not depend on the suction stroke of the engine, tar and other impurities may be removed from it by suitable devices, and hence, the use of bituminous coal, lignite, and peat is possible. Various details of design are modified by different manufacturers. Some of these changes are made simply to satisfy the requirements necessary to obtain a patent; others are made with the idea that they are decided improvements. A gas holder is also regarded by many as entirely unnecessary. Plants of several types are manufactured without such holders and are proving eminently satisfactory in commercial practice. In discarding the holder automatic devices must be introduced for controlling the pressure and the supply of gas to the engine.

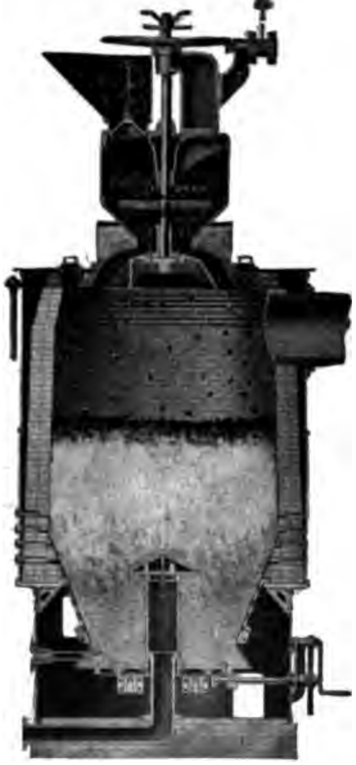

Fig. 316 Section of Gas Producer with Rotary Ash Table and Continuous Automatic Feed

Special Uses for Producer Gas. Besides furnishing gas for power purposes, producer gas systems are being found very desirable for special purposes in supplying heat for furnaces in chemical works; glass furnaces; brick, pottery, and terra cotta kilns; lime and cement kilns; sugar house char-kilns; silver-chlorination and ore-roasting furnaces; and, when suitably cleaned, it serves admirably for many low-temperature operations, such as laundry irons, can-soldering plants, etc., requiring small flame or jet work.

Hazards of Suction Producers. Taken as a whole the hazard introduced by a producer plant of the suction type, well installed and properly cared for, is small. Only producers which meet with the approval of the Laboratories should be allowed. When placed within the building, the room where the producer is installed should be a cut-off room of fire-resistive construction, well ventilated at top and bottom. Only metal-charging platforms and ash cans should be provided. Care should be taken when shutting down and lighting the burners. Vent connections should always be opened at such times. The heat energy of producer gas is about 125 B.T.U. As compared with naphtha gas (about 2,000 B.T.U.), this is very small. These figures give about the relative power of an explosion due to these gases. Explosions of producer gas have taken place and are usually due to tardiness in lighting burners when starting up, or neglect to turn off gas in producer when closing down. The explosions take place inside the apparatus and in all probability would relieve themselves either through the explosion vents installed for the purpose, or lift the poke hole vents or feeding device, since these are not tightly secured to top of producer. It should be noted that the installation of suction gas producers in cellars, basements, or other places where artificial light will be necessary for their operation, or where proper ventilation can not be obtained, is considered hazardous and should not be permitted except by special permission of the underwriters having jurisdiction. If the producer has a capacity of more than 250 h.p., it must be located in a detached building.

Hazards of Pressure Producers. Pressure systems are considered more hazardous than producers of the suction type. They should be located in a special building approved for the purpose, at such distance from other buildings as not to constitute an exposure thereto; nevertheless, approved pressure systems without gasometer, having a maximum capacity not exceeding 250 h.p. and with pressure in generator not exceeding two pounds, may be located in the building, provided that the generator and all apparatus connected therewith be located in a separate fireproof room, well ventilated from the outside of the building. In all other respects the apparatus must comply with the requirements for suction systems.

Electric Power. This convenient form of power has rapidly increased in extent and scope during the past few years. With the increasing interest in water power development, it is bound to find even greater use. The hazards of electric power are practically the same, whether the electricity is generated at a remote hydro-electric generating station or within the power house of the factory itself. All electric power systems and equipments should be installed in strict conformity to the National Electrical Code.

Hazards. All electrical apparatus have the inherent hazard incident to the production of heat. It is impossible to design a practical motor or generator in which the temperature of the coils will not increase when the machine is in operation. In a well-designed machine, run at the normal load, this heating is not dangerous under ordinary conditions.

Direct current motors should never be permitted in a building containing more than the average amount of dust, unless encased in strictly dust-proof cabinets or in separate rooms free from dust. Alternating current motors without slip-rings or starting commutator are generally considered free from fire hazards. However, the hazard from currents is greater in an induction motor than in a brush motor; and the rules for wiring these should be strictly followed.

Rheostats, such as are used for starting motors or controlling the voltage of generators, produce heat under normal working conditions. The ordinary starting box, if properly used, does not have current flowing through its resistance coils for more than a few minutes at a time. The current flowing in the field rheostat of a generator is too small to be dangerous. Speed-control rheostats are more likely to cause trouble, since they carry continually a comparatively large current.

Careless use of tools around live conductors, hasty boring of holes through partitions carrying charged cables, shipping of members and pinch-bars into the vicinity of bus-bars, and cutting out fuses by copper jumpers across the terminals are common troubles experienced in power stations.

Friction and Lubrication. The hazard of power resolves itself largely into one of friction, due to moving parts, and the value of proper lubrication to prevent fires should be understood.

Edward Atkinson, many years ago, noted that many destructive fires had originated from hot bearings especially on main shafts. A study of lubrication was made and it was found that in 55 mills of a certain class, where there was no good reason for any variation in the cost of lubrication, the average price paid for oil varied from twenty-nine cents to one dollar and five cents per gallon. In the investigation that followed, it was found that there was but one well-distilled and safe mineral oil for lubrication to be found, and that was made under a patent. The agitation which followed forced other manufacturers to adopt similar methods of manufacture and mineral lubricating oils are now made of various qualities more or less fluid and more or less filtered, but mostly free from objectionable vegetable oils, non-volatile, and with a greater uniformity in price.

Transmission. The principal means of transmitting power are by shafting, belt drives, chain drives, and direct-connected electric motors. The last may be eliminated from this part of the discussion as being a hazard of electricity, which has already been described. These hazards should be carefully investigated and properly guarded against.

Shafting. Many fires are caused by shafting. All shafting should be well hung and provided with self-oiling bearings. Bearings should be kept clean, and combustible material should not be allowed to collect on or around them. Shavings should not be placed in concealed spaces, especially where liable to catch flyings and other inflammable material. In sprinklered factories, shafting in low basements or in trenches, or in locations otherwise unprotected, should have lines of sprinklers overhead.

Belts and Pulleys. Numerous fires have been caused by pulleys, especially by the wood pulley and the loose pulley. The nature of belt used and the speed of the machinery are factors which influence the fire hazard. Exhaustive tests were made under the direction of the Miller's Mutual Fire Insurance Companies on the use of canvas belts, rubber belts, and leather belts on both wood and iron pulleys. Details of these tests are given in the October, 1911, *Quarterly* of the National Fire Protection Association. The experiments proved that the only safe combination is the canvas belt on an iron pulley. Increasing the pulley speed or increasing the tension on the belt undoubtedly increases the hazard. The tests with rubber belts on wood pulleys indicate that this is a very dangerous combination.

Belt Box Hazard. A very important hazard in connection with belt transmission is that of the belt box. The maximum danger of the spread of fire is to be found in conditions which admit of its going from story to story, especially if increased by construction which forms drafts. For this reason boxes or shafts for carrying belting should be fireproof and so arranged as to prevent the fire in lower stories from going into those above. The ideal in construction is where these belt boxes are in a fireproof building or tower, the driving pulleys being on the tower side with the bearing in the wall arranged for oiling on the mill side, so that the shaft works in a tight box through which fire can not pass. In many cases belts pass through floors without any protection whatever, or are carried in wood boxes which are dirty with flyings and ignitible fluff, besides being oil-soaked and liable to burn like tinder.

Rope Drive. Rope drives are coming into use quite extensively. In general, the hazard of transmission is much reduced by this method. However, it is frequently customary to enclose the rope drives in boxes, especially in positions where they have replaced shaft drives and would be exposed to the weather. Care must then be taken to see that the boxes or chutes are of ample size, to prevent the liability of the rope striking and grinding against the box. Rope drives should be located preferably in fireproof towers as described for belt drives.

Chain drives are also coming into more general use, and they offer an excellent means of transmission from the fire hazard point of view.

BOILERS, FLUES, AND STACKS

The ordinary low pressure boilers used for heating purposes have been treated under the head of "Heating". Boilers operating at a pressure above ten pounds are considered as high pressure boilers. Irrespective of the hazards of location, installation, and operation, fire insurance companies are indirectly much interested in the type and construction of boiler, since fires frequently follow a boiler explosion.

Description of Boilers. *Shell Boilers.* Boilers are divided into the two broad classes of shell and sectional. The latter type was mentioned under "Heating". The shells of boilers may be of lap seam or butt and strap construction. The edges of the boiler plates are either lapped over and riveted or brought edge to edge and then joined by a cover-plate, which is riveted to each of the two plates. The first mentioned makes a lap joint, and the second a butt joint. In both constructions the plates may be either single, double, or triple riveted, the strength being increased in each instance. A butt joint is always to be preferred over a lap joint; and in a few States, lap seam boilers are no longer allowed for high-pressure work. Butt joints may have two cover-plates, one outside and one inside. The outer cover-plate is narrow with rivets placed close enough together to provide for sound calking. The inner plate is wider, and as its edges are not calked they may have a row of more widely spaced rivets. Fig. 317 illustrates a lap joint and Fig. 318 illustrates a triple riveted butt joint, with two cover-plates.

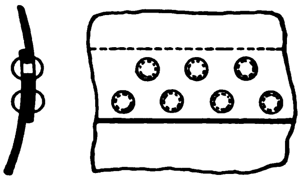

Fig. 317. Lap Seam—Double Riveted

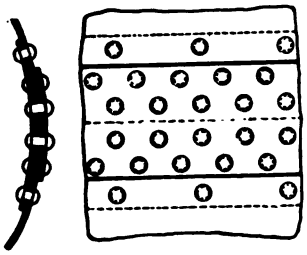

Fig. 318. Butt and Strap Joint—Triple Riveted

Tubular Boilers. Boilers are of the cylindrical tubular type or water tube boilers which are a combination of shell and sectional. The tubular boilers have an external shell made as described, containing a large body of water. Heat is communicated to the water through the shells or through the sides of internal furnaces, and also by carrying the gases through tubes or flues. The ordinary tubu-

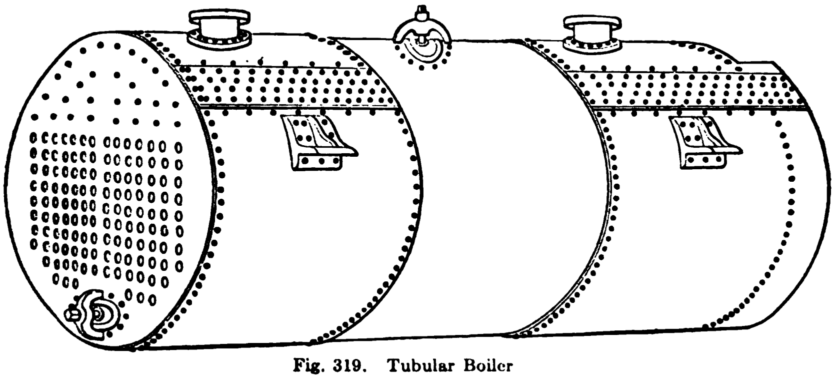

Fig. 319. Tubular Boiler

lar boilers, Fig. 319, have numerous fire tubes passing through, commonly having a diameter of 3 or 4 inches. About two-thirds of the volume of the boiler is filled with water, the other third being reserved for steam. The water line is 6 to 8 inches above the top row of tubes.

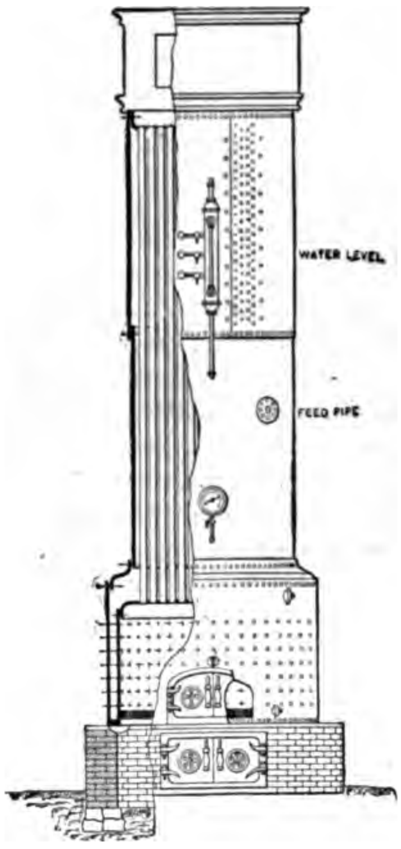

Fig. 320. Vertical Boiler

Locomotive Boilers. Boilers of the locomotive type are often used for small factories, or where steam is required temporarily. The locomotive boiler consists essentially of a rectangular fire-box and a cylindrical barrel through which numerous tubes pass from the fire-box to the smoke-box. These form a continuation of the barrel, and furnish a vent for the products of combustion to pass up the smoke-stack. The tubes are smaller and spaced closer together than in the ordinary tubular boiler, and the boiler operates under a strong forced draft produced by throwing the exhaust up the smoke-stack. This type has no permanent foundation, but it is supported on brackets at the fire-box and by a pedestal bearing on rollers near the back end.

Flue Boilers. The cylindrical flue boiler differs from the tubular boiler mainly in replacing the fire tubes by one or more large flues. This type of boiler is usually longer than a tubular boiler, but it has less heating surface and is less efficient in the use of coal. Its great simplicity and accessibility for cleaning recommend it where feed water is bad. In places where fuel is very cheap, especially where it is a waste product as at sawmills, the plain one-flue cylindrical boiler is frequently used. Boilers of this type may have two flues or modifications of these, such as the Lancashire and Galloway boilers.

Scotch Marine Boilers. This is a type of marine boiler which is sometimes adopted for service on land and has a combination of two or more flues, which also contain the combustion chambers and fire tubes.

Vertical Boilers. The boilers previously mentioned are horizontal. Vertical boilers, such as the Manning, Fig. 320, have found favor at factories where floor space is valuable, since a powerful battery of boilers may be placed in a small fire room. They have a cylindrical shell with a fire-box in the lower end and with the fire tubes running from the furnace to the top of the boiler. This type of boiler also offers a large superheating surface, and steam under high pressure is readily available.

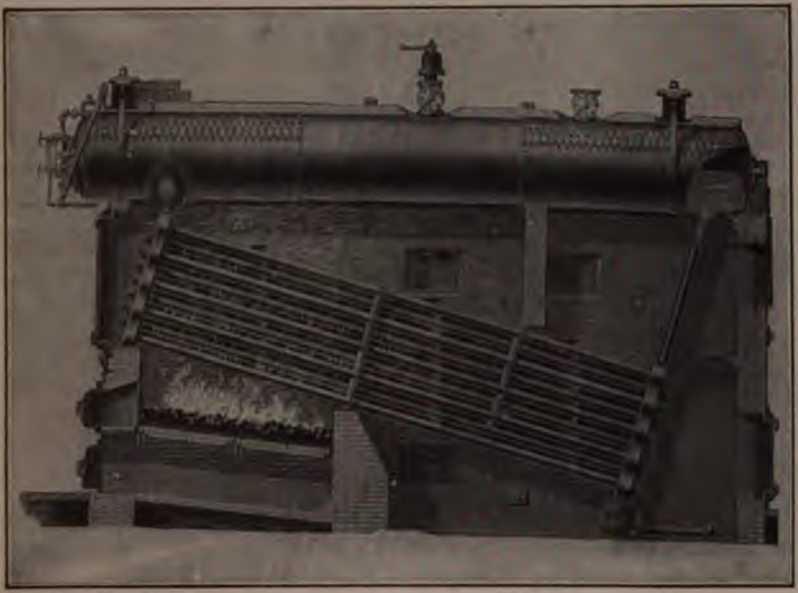

Fig. 321. Water-Tube Boiler (Babcock and Wilcox)

Water Tube Boilers. Water tube boilers, Fig. 321, of all sorts of shapes and methods of construction have been devised to overcome the admitted defects of shell boilers. Important types found in general use are the Babcock and Wilcox, Heine, and Stirling.

They all have the larger part of their heating surface made up of tubes of moderate size filled with water. They all have some form of separators, drum, or reservoir in which the steam is separated from the water; some of these boilers have a shell of considerable size, thus securing a store of hot water and a good free water surface for disengagement of steam. Such shell, drum, or reservoir is either kept away from the fire or is reached only by gases that have already passed over the surface of water tubes. Tubes are of moderate diameter and can be made abundantly strong.

Boiler Hazards. *Tubular Boilers.* The cylindrical tubular boilers and the water contained therein are heavy and cumbersome, and the shells under high pressure must be made very thick. Boiler scale, which consists of lime and other matter deposited from the water on the boiler shells and around the tubes, forms a dangerous condition. If the boiler fails, either through some defect or through carelessness of attendants, a disastrous explosion is likely to take place. If properly designed and made with butt and strap-jointed shells, and if cared for by competent and careful attendants, they have proved safe, reliable, and durable. The large mass of hot water tends to keep a steady pressure, though at the the expense of rapidity of raising steam or of meeting a sudden demand for more steam. This should be taken into consideration when laying out fire protection where steam pumps are to be advised.

Water Tube Boilers. Water tube boilers are admitted to be the safest type of boilers in use. If a tube does fail through defect in manufacture or through wasting during service, it will not cause a true explosion. Water tube boilers may be made light, powerful, and compact; they are well adapted for use with forced draft; and they will raise steam rapidly from cold water.

Dutch Ovens. Most boilers are heated by internally fired furnaces. Under certain conditions an externally fired furnace is desirable. An example of such is the Dutch oven or bulldog furnace, Fig. 322. This is simply an extension built in front of the boiler into which the fire grates are placed rather than put inside of the boiler wall proper, and underneath the front end of the boiler. The details of construction differ, but the general idea is the same in all cases. These ovens are generally built about 10 feet long; they should be fully as wide, and can very well be wider than the boiler front itself. These ovens are frequently found in wood-burning localities and in woodworking plants which consume large amounts of refuse. All kinds of culls, sawdust, bark, etc., can be thrown into them without much effort, thus making them both a labor saver and the most economical furnace for this purpose.

Protection Against Hazards. The illustration shows the sawdust being conveyed direct to the furnace through the blowpipe. It can be dropped in, equally as well, with a chain conveyor. There should be an extra large opening on top to allow the fireman to shovel or scrape the larger refuse into the furnace from the floor level. The blowpipe or chain conveyor should be so arranged as to have an extra leg or side extension attached with a switch or damper which can be thrown to one side when no fuel is desired directly under the boiler. Under such conditions the fuel should not be piled on top of the oven; in this case the fuel might easily ignite. It is needless to say that platforms of wood built up to the level of the oven floor should be protected. This is frequently a rather hazardous arrangement and carelessly operated. They do not appear, however, to have caused many fires, in fact, they are undoubtedly less hazardous than ordinary boilers burning this class of fuel.

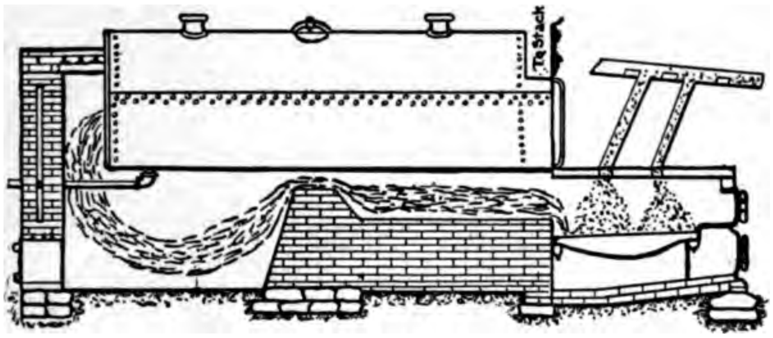

Fig. 322. Dutch Oven

Hazards of Location and Installation. Boilers have certain hazards of location and installation for which a number of rules and requirements have been prescribed to meet varying conditions. In general, a power boiler should preferably be located in a one-story brick building of good mill or fire-resistive construction and detached at least 25 feet. If adjacent to main plant, it should be well cut off from it. A fireproof roof is recommended for boiler houses and if this is used, the walls between boiler house and adjoining buildings need not be treated as a fire wall above the level of boiler-house roof. If located within a main building, more rigid requirements for installation and protection of rooms are provided. Here boilers should be encased in brick and located 36 inches away from side walls of room if of combustible material. If the boiler is not encased, this clearance should be 48 inches. Floors must be of non-combustible material. Combustible ceilings over boilers should have no concealed spaces and should be protected by at least two good coats of whitewash or fire-retardant paint which will need to be renewed as occasion demands. Wood or metal sheathing, plastering, etc., should be removed and the ceiling left unfinished so as to be readily accessible for inspection, whatever protection is necessary, aside from the above-mentioned paint or whitewash, being placed upon the boiler.

Clearance. Between the unprotected arch or breeching (smoke-flue) of boiler and combustible ceiling or material there should be a clearance of not less than 36 inches. This may be reduced to 18 inches, if the breeching is arched with brick or covered with at least 3 inches of asbestos cement, or its equivalent. The clearance may be reduced 10 inches, in one-story boiler houses, if the breeching is protected with 3 inches of asbestos cement, provided there is ample ventilation over it to the outside air. Breeching should be protected on sides as well as on top. The dome of a boiler is simply a large steam holder and may be treated, as far as concerns clearance, with large steam pipes; except that, in case it is located between joists or is otherwise pocketed, it should have at least a 3-inch clearance and be protected with 2 inches of asbestos cement having smooth finish. Unless there is a clearance of 6 to 8 feet between flue or boiler and roof, boiler rooms should be provided with ventilators.

Boilers on Wood Floors. Boilers set over wood floors should be arranged as follows: On the floor, place a sheet iron or steel plate not less than three-sixteenths inch in thickness, extending at least 5 feet in front of, and 2 feet on all other sides of, boiler or boilers; this plate must be securely riveted at joints and turned up 5 inches at edges all around; on top of plate, place at least 5 inches of brick set in cement mortar; on top of the brick, cover the space directly under the boiler with 6-inch hollow fire-tile covered with three-sixteenths inch steel plate.

Hazards of Use. Boilers have certain hazards of use beside the explosive feature. Combustible material, such as refuse and sweepings in the boiler room, is a common cause of fire. Such material if not burned at once should be kept in a fireproof bin or vault cut off from the boiler house. This is mentioned in more detail under "Fuel." The use of shavings for fuel is hazardous, not only because of the creeping of fire from beneath the grate bars by the loose shavings around the doors, but because of the danger of what is known as a "back draft," which is a common cause of fire in planing mills. When the draft of the chimney fails, or is poor, as it sometimes is in damp weather, the entire contents of the furnace may be thrown out into the shavings vault or adjacent room. The furnace feed, therefore, should not be in line with any communication with the main structure but at right angles to it, so that in case of a back draft, the burning contents of the furnace can not be thrown into the other rooms of the risk. Where shavings and refuse are used as fuel, they are frequently fed automatically direct to the fire-box. Such an arrangement is shown in Fig. 323.

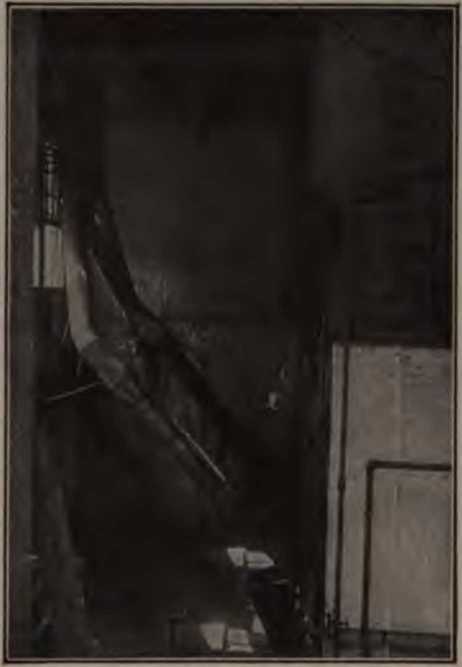

Fig. 323. Automatic Furnace Feed

A common cause of fire is sparks from boiler stack. Where wood is used for fuel, the stack should be provided with a spark arrester or proper deflectors built in the base of stack. Fires occasionally start in material which has been stored in some shed or box adjacent to the side of the boiler. The storage of wood fuel to dry, and the accumulation of dust, dirt, and rubbish on top of boilers should not be allowed. Fires from this cause are not frequent but possible, as experience has shown. Operating boilers under forced draft and excess load for the work designed is likely to be a dangerous procedure.

Boiler Economizer. An economizer is an arrangement whereby it is possible to get heat from the products of combustion by passing them through a feed-water heater after they leave the boiler and before they enter the chimney. The economizer most commonly found is the Green. It is made of several sets of vertical cast-iron tubes 4 inches in diameter, placed in a chamber between the boiler and the chimney. The feed water is pumped in succession through the several sets of tubes beginning at the more remote and finally passing from the nearer tubes to the boiler. This arrangement brings the hottest water in contact with the hottest gases. There are scrapers arranged in sets, one on each tube. By power from a small steam engine or elsewhere, the scrapers are continually moved up and down on the pipes in order to keep the pipes free from soot and in good condition to take up heat. Economizers are cleaned by blowing steam through the tubes which carry out the soot. Care must be used in the disposal of this soot. It is heated and may cause fire if it comes in contact with inflammable material. Woodwork must not be allowed to come in contact with the economizer. The hot gases give off sufficient heat to carbonize and ignite inflammable material.

Smokestacks. Smokestacks should be built according to the regulations of the local building code, or in lieu of any regulations applying, then according to requirements of the building code recommended by the National Board of Fire Underwriters. Stacks should be built preferably of heavy brick, stone, or concrete from the ground to a point 10 feet or more above peak of highest roof. A metal stack on a concrete base outside of building is allowable under the regulations of the National Board. Where this is done it would be best to build a brick, stone, or concrete base at least 5 feet above roof of boiler house. The metal portion of stack should be well guyed with iron stay-rods or chains, and painted with asphaltum every year. Breeching should enter stack at least 4 feet below roof

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of boiler house and have at least 36 inches clearance to combustible material. Stack should be lined with fire-clay brick laid in fire-clay mortar where breeching enters.

Metal Stacks. If a metal stack passes through a roof it should have proper clearance and be provided with a ventilated jacket. There is little danger from the effect of heat radiated from the iron stack upon wood nearby, unless the wood is in actual contact with, or in very close proximity to the stack. The following description is given of the protection devised by the John C. Paige Insurance Agency, Boston, Mass.; and complete details of construction and dimensions for various sized stack were published in the October, 1911, *Quarterly* of the National Fire Protection Association.

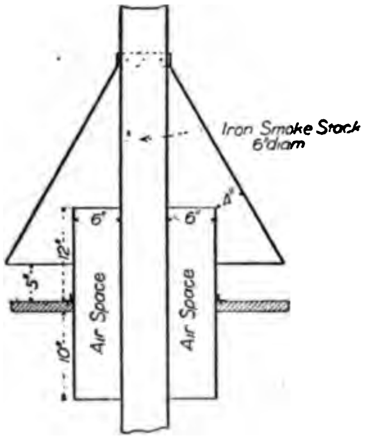

Fig. 324. Cross Section of Smoke-Stack Protection

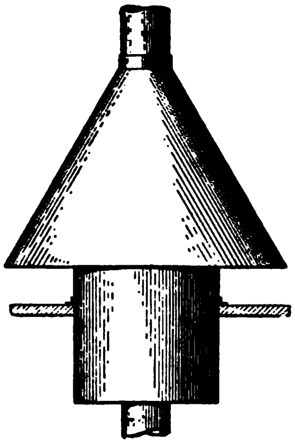

Fig. 325. View of Completed Stack Protection

Fig. 324 shows a cross section of the stack. Fig. 325 shows a view of the whole arrangement. The amount of radiation from a stack 24 inches in diameter is no more, and if anything is less, than from a 6 inch stack; hence an air space of 6 inches is thought to be ample for all sizes above 6 inches. The theory upon which this protection for stacks is based depends upon the fact that there is a considerable difference in temperature below and above the boiler room roof which will cause a condensation, within the stack at the roof line, of the acid products of combustion, especially of the pyroligneous and acetic products. These hot acid products will eventually corrode the stack sufficiently to cause holes. The tendency of the smoke and gas is to pass up the stack in a centrifugal course seeking an outlet, and a spark will soon find even a minute hole through which it may lodge on the adjacent woodwork of the roof. The effect of the collar and umbrella, therefore, is to form an air space of equal temperature at the roof line through which the air from below can readily pass out of doors, thus reducing the liability of any condensation in the stack at or near this point. The collar is extended below the roof sufficiently to protect the roof joist timbers against lodgment of sparks.

For stacks of wood-burning or direct flue boilers, where stacks are hot, the double collar and umbrella arrangement is recommended. Fig. 326 shows a view and partial cross section of this arrangement.

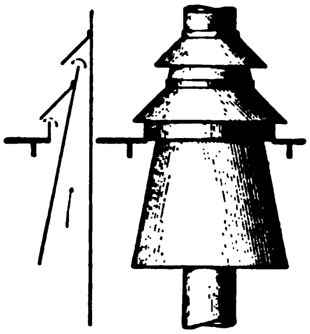

Fig. 326. Special Arrangement for Wood-Burning Boilers

Metal stacks through floors are very dangerous and their use should be prohibited.

FUEL AND ASHES

The storage and handling of fuels offer a fruitful source of trouble. The most prominent hazardous fuels are shavings and wood refuse, soft coal, charcoal, and oil fuels. Coke offers very little hazard, although cases of spontaneous heating in coke piles have been noted. Tanneries, where bark is used, frequently burn the spent tan bark under the boilers. When this is done the feed should be constant so as to consume the spent tan bark as fast as it accumulates, as it is liable to spontaneous heating and ignition if stored in heaps while moist.

Wood Shavings and Refuse. In the northern and wooded sections, log wood is frequently used for fuel and much wood is consumed in the homes. In woodworking plants wood refuse, shavings, sawdust, etc., are used in some places as a method of disposal, and in others as their only source of heat energy. These plants are generally equipped with efficient blower systems for sucking up and conveying the material to the boiler room or storage vaults. The air is allowed to escape through what is known as a cyclone separator, the material dropping gently into its proper place as fed directly to the boilers. Shavings vaults are frequently within the boiler room, adjacent thereto, or in sheds close by. When within the boiler room or adjacent thereto, they should consist of fireproof or cut-off rooms or vaults. Fig. 327 shows a Standard Shavings Vault in a boiler room, with the cyclone separator above and automatic feed to boiler.

Coal. Many fires are due to the spontaneous heating of coal in storage. The Bureau of Mines has made an exhaustive study of this subject and the following facts have been gleaned from the work of Horace Porter and F. K. Ovitz,* engineers in the service of that Bureau. Oxidation, probably in the main an absorption of oxygen by the unsaturated chemical compounds in the coal substance, begins at ordinary temperature in any coal, attacking the surfaces of the particles, thus slowly developing heat. In a small mass of coal this slowly developed heat can readily dissipate itself by radiation and no rise in temperature results. If radiation is restricted, however, as in a large pile densely packed, the temperature slowly rises. When storage conditions are such as to allow a

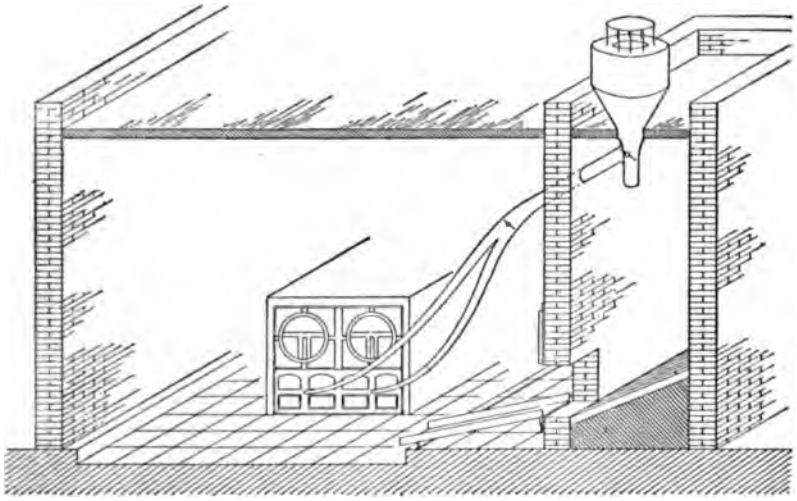

Fig 327. Standard Shavings Vault

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*Paper presented at a joint meeting of the New York Section, American Chemical Society, American Electro-Chemical Society, and the Society of Chemical Industry, November 10, 1911.

temperature of about 200 degrees to be passed, the rate of oxidation is great enough ordinarily so that the heat developed overbalances the heat radiated; and the temperature will rise to the ignition point if the air supply is adequate. It is important, therefore, to guard against even moderate heating in the coal either from internal spontaneous causes or by radiation from external sources.

Hazard of Dust. The amount of surface exposed to oxidation in a given mass depends on the size of the particles and increases very rapidly as the fineness approaches that of dust. Dust is therefore a dangerous thing in a coal pile, particularly if it is mixed with larger-sized coal which forms air passages to the interior. Spontaneous combustion is brought about by slow oxidation in an air supply sufficient to support the oxidation but insufficient to carry away all the heat formed. There is a wide variation among coals in their ability to withstand pulverizing. In comparative rattler tests under certain standard conditions, Pocahontas, New River, and Cambria County (Pa.), coals produced nearly twice as much (through one-eighth-inch screen) as a sample from the Pittsburgh seam. This is a large factor in spontaneous combustion. Mixed lump and fine, *i.e.*, run-of-mine, with a large percentage of dust, and piled so as to admit to the interior a limited supply of air, make ideal conditions for spontaneous heating.

Pocahontas Coal. Pocahontas coal gives a great deal of trouble with spontaneous fires in the large storage piles at Panama. It is reported also by several large by-product-coke concerns to be more troublesome in this respect than their high-volatile gas coals. The high-volatile coals of the West are, to be sure, usually very liable to spontaneous heating; but they owe this property to the chemical nature of the substances which compose the coal, rather than to the amount of volatile matter.

Effects of Moisture. The influence of moisture and that of sulphur upon spontaneous heating of coal are mooted questions much discussed, not very much actually investigated, and certainly not yet settled.

Seasoning. Freshly mined coal and even fresh surfaces exposed by crushing lump coal exhibit a remarkable avidity for oxygen; but after a time they become coated with oxidized material, "seasoned", as it were, so that the action of the air becomes much less vigor-ous. It is found in practice that if coal which has been stored for six weeks or two months and has even become already somewhat heated, be rehandled and thoroughly cooled by the air, spontaneous heating rarely begins again.

Storage Under Water. Storage of coal under water is being practiced at some large plants. The fact that this practically necessitates firing wet coal becomes an important factor with coals like the Illinois and Wyoming types, which mechanically retain five to fifteen per cent of water after draining. Submergence storage is an absolute preventive of spontaneous combustion, and on that account alone, its use may be justified with some coals. But merely for the sake of the saving to be secured by avoidance of weathering, there does not seem to be good ground for its use.

Precautions for Storing Coal. The following recommendations are offered as being advisable precautions for safety in storing coal whenever their use does not involve an unreasonable expense. It must be remembered that any or all of these recommendations may under certain conditions be found impracticable.

(1) Do not pile over 12 feet deep, nor so that any point in the interior will be over 10 feet from an air-cooled surface.

(2) If possible, store only lump.

(3) Keep dust out as much as possible; therefore reduce handling to a minimum.

(4) Pile so that lump and fine are distributed as evenly as possible; not as is often done, allowing lumps to roll down from a peak and form air passages at the bottom.

(5) Rehandle and screen after two months.

(6) Keep away external sources of heat even though moderate in degree.

(7) Allow six weeks' "seasoning" after mining before storing.

(8) Avoid alternate wetting and drying.

(9) Avoid admission of air to interior of pile through interstices around foreign objects such as timbers or irregular brickwork; also through porous bottoms such as coarse cinders.

(10) Do not try to ventilate by pipes as more harm is often done than good.

Charcoal. *Occlusion of Gases.* The storage and handling of charcoal introduces a distinct hazard. Just as a sponge absorbs water, so the innumerable pores of all kinds of charcoal possess an extraordinary affinity for moisture, gases, and vapors. The charcoal is said to occlude gas and this phenomenon is called the occlusion of gases by charcoal. This phenomenon is accompanied by heat, and spontaneous ignition is liable to take place. The risk of this phenomenon occurring is the greater in proportion as the charcoal is freshly made and the hotter it is at the time of its exposure to the air. The danger disappears in the course of two or three days; if the charcoal be meanwhile kept away from the air and only exposed thereto when thoroughly cool, the absorption of gas proceeds but gradually. This precaution, being essential to safety, should be adopted in all cases. Old charcoal will attain the same danger as is manifested in this respect by that newly prepared, if it be heated up again, the heat expelling the occluded gases and revivifying the absorptive power.

Effect of Moisture. Moistening charcoal will powerfully stimulate its tendency to take fire spontaneously after re-drying. In this case the moisture expels the occluded gases just as is effected by heating to incandescence. So long as the liquid occupies the pores, the charcoal is safe until it evaporates in drying and leaves the pores empty again.

Hazards of Transportation. In 1911, there were sixty-four fires in the transportation of charcoal in the United States reported to the Bureau for the Safe Transportation of Explosives and Other Dangerous Articles. During the same year that Bureau conducted experiments on the spontaneous heating and ignition of hardwood charcoal. After varying treatment as to cooling and air exposure, the charcoal was loaded into box-cars, and the temperature of the interior of these cars was observed at intervals to detect any increase in temperature.

Results of Experiments on Cooling and Airing. From the incomplete experiments performed,* it was reported that no conclusions could be drawn as to the relative efficiency of various periods of cooling and airing. In no case was there any ignition or an increase of temperature approaching ignition. In every case but one there was a noticeable rise of temperature which could be ascribed only to the action of air on the cold charcoal and not to any residual sparks or fire. The report states that, in order to attain absolute security from fires of spontaneous origin, it is necessary to store the charcoal in the open until such time as it will attain its equilibrium with regard to absorption of air. This being impracticable, it is suggested that the present practice of cooling, airing, and storing in open car for twenty-four hours prior to shipment be supplemented by a safe method of ventilation of cars during shipment.

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*Bureau for the Safe Transportation of Explosives and Other Dangerous Articles, Report No. 5, February, 1912, page 47.

Hazardous Conditions. Greasy charcoal may easily ignite of its own accord. Solid substances which, although apparently dry, give off moisture and also liberate oxygen when gently heated, are just as dangerous to charcoal as are moisture and gases (oxygen in particular). Charcoal should not be stored nor placed in contact with hygroscopic substances (calcium chloride, magnesium chloride), which by their attraction for water and moisture may saturate the charcoal with water; the same applies to metallic sulphides with an affinity for oxygen, and to ozone, liquid oxygen, oil of turpentine, and all substances that readily part with oxygen.

New parcels of powdered or coarse charcoal should be handled with suspicion, since from some unknown cause (freshness, recalcination, drying, or moisture), they may contain the germ of a spontaneous outbreak of fire, still indetectable. During the first three days after arrival, the goods should be stored away from inflammable material or in a fireproof room, or else the internal temperature of the mass should be controlled by frequent readings, since it takes fully three days to learn whether the tendency to spontaneous ignition really exists or not. These precautions are particularly necessary when the charcoal is tightly packed.

Liquid Fuels. *Fuel Oil.* Mineral oil in the forms of crude petroleum or refuse heavy oil direct from the distillation of the petroleum—generally known as fuel oil—is being used to an increasing extent. It is customary to force the oil into the furnace in the form of finely divided spray through special spraying apparatus worked either with compressed air or with superheated steam. The use of superheated steam has only its convenience to recommend it, for it adds to the inert material to be uselessly heated. Special precautions must be taken when petroleum is burned, to avoid flooding the furnace with oil and to prevent explosion of the vapor and burning of the oil in tanks or receptacles. The problem introduced by this is principally one of storage, although the burners should be only such as have met the approval of the laboratory examinations, and have been installed in strict conformity to rules which have been provided. The methods of storage are very important and the rules for storage and use of fuel oil should be strictly observed.

Gasoline, Kerosene, and Alcohol. The proper use of these volatile oils was mentioned in the discussion of the devices and apparatus using them. The rules governing the storage of these materials should be strictly observed. Further reference to their characteristics is made in the section entitled "Use and Storage of Inflammables, Volatiles, and Explosives."

Ashes and Cinders. These are old offenders. An ordinance of the City of London, which was passed in 1667, contained the following: "That every inhabitant prepare some secure place in his dwelling (not under or near any staircase) to lay in his sea coal ashes, embers, or any other sort of fire ashes, and that the said ashes be quenched with water every night before going to bed." Ashes should always be kept in approved metal ash cans made according to the Rules and Requirements, or they may be placed on an incombustible floor, provided there be no storage of combustible stock nearby, but they must in no case be allowed even temporarily to be dumped on a wood floor, nor against combustible walls, partitions, posts, etc., nor stored in wood receptacles. In dwelling houses, etc., a favorite custom is to utilize dark waste spaces under stairways to dump ashes into wood boxes, etc. It is recommended that cans used for dumping ashes into wagons, and consequently subjected to severe service, be constructed in a very substantial manner. In a few large power plants, ashes are discharged by a vacuum conveyor system into an ash bunker built above the boilers, from which they are chuted to cars and taken away. The same vacuum system is used for removing soot from the economizers.

LIGHTNING

Importance of Lightning Hazard. *Extent of Damage.* Just how much damage is caused by lightning in the United States is difficult to determine. It is claimed that more lives are lost by lightning than by violent winds and tornadoes. The United States Weather Bureau in 1890 started a statistical inquiry and kept a record for ten years, after which the work was abandoned on account of not being successful in gathering complete information. However, during the year of 1900 alone, their incomplete reports showed that 713 persons were killed by lightning or injured fatally, and that thousands of dollars worth of property was destroyed annually by this dreaded element.

During the summer of 1911, the Department of Physics at the Ontario Agricultural College, with a view to securing information upon the subject, sent letters to a large number of insurance companies doing business in Ontario. Forty of the companies replied in a sufficiently definite manner to make tabulations of their replies possible. From these it appeared that, of all the rural house claims settled during an average period of twelve and a half years, 26.8 per cent were due to lightning. Of all the barn claims settled during the same period, 66¼ per cent were due to lightning. Including both barns and houses it was found that of all rural claims paid during that time, 45.4 per cent were due to lightning. Of all these buildings which were struck, 21.4 per cent were completely destroyed.

Comparison of Losses on Rodded and Unprotected Buildings. In Minnesota during 1911 there were 145 fires from lightning entailing a loss of $141,364. The office of State Fire Marshal did not receive during the year a single report of a building having been struck that was properly rodded. The fire marshal of Ohio reported no loss on a rodded building, although there were fired in the state during the year 129 barns, 38 dwellings, seven churches, and 22 other structures and haystacks with losses aggregating $236,895. Maine reported 350 lightning fires, and Texas 188. Farm Mutual Insurance Companies find two-thirds to three-fourths of their losses are from lightning on unrodded buildings. Of forty companies represented in an annual meeting of the Indiana State Association not one had a lightning loss on a rodded building. The report of sixty-four mutual fire insurance companies of Ohio and Pennsylvania for 1911 shows $107,164 loss from lightning on unprotected buildings, and only $142 on buildings that were protected against lightning. Professor Jos. Henry, Secretary, Smithsonian Institute, Washington, D. C., states that in a house properly provided with lightning conductors, however many discharges may fall on it, we are well assured from full experience and established principles that no damage can come to the occupants within.

Lightning Investigation. *Ancient.* From the earliest times this great manifestation of the power of nature has been a source of constant conjecture to the minds of all learned men. In the middle of the Eighteenth Century the subject of atmospheric electricity attracted widespread attention. Franklin in America, de Romas and D'Alibard in France, Divisch in Bohemia, Toaldo in Italy, and Richmann in Russia believed in the efficiency of pointed conductors for the purpose of exploration and protection. But it was Franklin who had the clearest vision of them all. He wrote in 1749: "May not the knowledge of this power of points be of use to mankind in preserving houses, churches, ships, etc., from the stroke of lightning by directing us to fix, on the highest points of those edifices, upright rods of iron made sharp as a needle, and gilt to prevent rusting; and from the foot of those rods a wire down the outside of the building into the ground, or around the shrouds of a ship and down her side till it reaches the waters? Would not these pointed rods probably draw the electrical fire silently out of a cloud before it came nigh enough to strike, and thereby secure us from that most sudden and terrible mischief?" In June, 1752, Franklin with the aid of his son raised his spiked kite in one of the fields of Philadelphia and definitely proved, by unassailable experiments made in that field and under the canopy of heaven, his contention that the electricity of the atmosphere was identical in kind with that of the frictional electric machine of his laboratory. He then propounded the principle of his famous "Franklinian" rod. Yet in spite of the results which the other investigators obtained and the explanations which they gave, it was a long time before leaders and people looked favorably upon the theories of Franklin.

Modern. The present facts concerning lightning have been attained after years of the most patient investigations on the part of men like Sir Oliver Lodge; Hon. Killingworth Hedges, Secretary to the Lightning Rod Conference of 1905; Professor Willis S. Moore, Chief, United States Weather Bureau; Professor Alex. McAdie; Elihu Thompson; and many others. Two famous lightning-rod conferences were held in England, but the one in 1905 may be considered to be the beginning of the present universally accepted theories as to the phenomena of lightning and the scientific protection against its ravages. In light of the facts presented and the discussions which followed, opinions were crystallized and differences moulded into a unanimous and harmonious whole.

Present Theories. *Atmospheric Electricity.* Electricity in the air is due to evaporation of moisture from the surface of the earth, changes of temperature in the atmospheric vapor, chemical action on the earth's surface, and the friction of volumes of air of different densities against each other. When electricity is excited in the atmosphere by any natural cause, it is received by the clouds. They are fairly good conductors of electricity, and in passing through the air which contains much free electricity, they collect and retain large quantities of it and thus become electrified bodies. Through the law of induction, one cloud becomes charged with positive electricity and this will induce an opposite negative charge in its neighbor. The earth and the objects upon it, beneath an electrified cloud, are oppositely charged.

Lightning Flash. Two clouds being in different electrical states, or oppositely electrified, may act upon each other through the intervening air and when sufficiently near to each other may permit the attraction between the positive and the negative electricities to overcome the resistance offered by the air. A disruptive discharge then occurs. The rapid passage of the electricity forcing its way through the air produces intense heat which manifests itself as the lightning flash. The violent report and rumbling noise which succeed lightning are known as thunder and are generally supposed to be caused by the sudden separation and reunion of the air through which a disruptive charge has taken place and due to sudden expansion and compression all round caused by the heated air, which is followed by a sudden rush of air into the partial vacuum thus produced.

Lightning Stroke. When a cloud or layer of clouds has acquired a sufficient extent and approaches within a suitable distance of the earth, being oppositely electrified, a discharge takes place between them. This is known as a lightning stroke and is the attempt of the two electricites to gain an equilibrium. The electricity passes at the same instant from the earth toward the cloud and from the cloud toward the earth. All the damage usually done by lightning is caused by electricity passing from the earth upward. The accumulation of free electricity upon buildings offers attraction to the opposite electricity contained in the electrified cloud, and this causes them to be struck by lightning. There are circumstances when the discharge may come from the clouds to the earth, and it is a fact that there are often discharges from cloud to cloud. But the opinion of the best-known writers is that the destructive discharges which we call thunder bolts come from the earth through the objects upon its surface, and thus destroy them.

Force of Lightning. A lightning stroke travels at a speed of 186,000 miles per second. It is estimated that a stroke of lightning one mile long represents 500 million volts. This energy, if bottled up in a storage battery, would drive all of the electric street cars of a metropolis for several hours; or light a 15-power incandescent lamp for twenty years. It is this electrical energy of lightning that kills and detaches blocks of masonry and causes buildings to burn.

Theory of Rodding. Lightning rods are not placed on buildings for the purpose of inviting a lightning stroke, as was at one time thought to be their purpose. A building made of wood, brick, or stone serves as a condenser or storehouse in which electrical energy will collect. Such buildings are in direct opposition to nature's laws, for it has been noted that during a thunder storm electrical energy fuses or wastes away from all vegetation such as trees, growing crops, etc., caused by the attraction of the electricity of the atmosphere and clouds. This same attraction induces electricity into a building from the earth and in accordance with nature's laws. Lightning rods installed on a building allow this continuous fusing or wasting away of electrical energy, thus relieving the electrical stress between the cloud and earth or building which, when broken down, allows the lightning stroke. Hence, the necessity for sharp points on the ends of the rods, close contact with the building and all metal parts thereon, and well-grounded terminations of the rods. If a rupture does occur in the air between earth and cloud, the lightning then passes downward safely to earth through the rods.

Suggestions for Proper Protection. *Rods.* For a long time copper was considered the only material for lightning rods, the reason being that copper conducts a steady current of electricity six times as well as iron. Sir Oliver Lodge, in 1892, carried on experiments which proved that an iron wire would carry off a sudden rush of electricity better than copper of the same size. As we have learned, lightning rods have two functions to perform: (1) that of carrying off the flash in case the building is struck; and (2) the greater duty of preventing strokes from occurring by the gradual flow of electricity along the rod to the point and into the air. Thus we see that for the one purpose an iron rod is the best, and for the other a copper rod. Taking into consideration the question of durability, perhaps copper on the whole is a somewhat better material than iron. However, there is no doubt that a building properly rodded with iron rods is protected in a very large measure. The best rods for the price are those made of galvanized steel, and these may have a sheathing of copper if desired. The latter arrangement would seem to be very desirable, and the extra cost of about one-half more seems justified, in view of the greater durability and added security. It is said that four-fifths of the rods in use are of the star variety; that is, a cross section looks like a star. The reason for this is due to the theory that electricity flows along the surface of a conductor; thus the greater the superficial surface is, the greater the conductivity; hence comes the advantage of rods cast in this shape. They are twisted also to add rigidity, and they have screw and cup, one at each end, for jointing.

Installation. Conductors should never be insulated but should be fastened securely in place against the building with suitable allowance made for an expansion by clamps of the same material as the conductors. The vertical rods should be carried a sufficient distance from the wall to avoid sharp bends around projections, and in all cases as straight a run as possible should be provided.

All prominent points, such as spires, cupolas, observatories, ventilators, chimneys, and gables, must be furnished with a rod and point. After such prominent parts of the building are protected, surfaces of plain roof must be protected according to the rule that there shall be no stretches of ridge of more than 30 feet between points. The points and point rods as above must be furnished with discharging rods according to the rule that there shall never be less than two rods to the ground on any building, and never more than eight points to two discharging rods on any circuit system of rods; and should the building require more than eight points, it will be necessary to have an additional discharging rod. All metallic bodies should be connected to the lightning rod. If the metal body is a long one, like a steel track, it would probably be best to attach it to the system at both ends. Wherever one metal ramification approaches another, it is best to connect them metallically. All the cables on one building should be connected into one system. Divided systems should be scrupulously avoided. If the conductor at any point of the course goes near water or gas mains, it is best to connect it with them. The neighborhood of small bore, fusible gas pipes and indoor gas pipes in general should be avoided. Ground rods must terminate with copper earth plates bedded in charcoal; or have good electrical contact with some water pipe or cistern, cesspool, or well.

Wire fences should be grounded at every eighth post. A great loss has resulted to cattle which have assembled near wire fences during storms. Ships are now all protected against lightning, having their conductors grounded below the surface of the water.

LOCOMOTIVE SPARKS

The hazard of locomotive sparks is one of great importance, but it has not received due recognition in this country. The electrification of our railroads in congested centers and the use of oil-burning locomotives in wooded territory should be strongly advocated.

Magnitude of the Losses. The United States District Forester for Montana and Idaho estimated a loss to the Government and to adjoining timber of 6,000,000,000 feet, or a total of $21,500,000 caused by 1,670 fires, 56 per cent of which started on the railroad rights of way and in spite of good co-operation by the railroads. Many of the great forest fires in Minnesota, which have caused such loss of life and suffering and the destruction of so much valuable property and timber, have been due to fires which were started by locomotive sparks.

Four fire insurance companies which make a specialty of insuring flour mills and elevators paid more than $160,000 in 1910 for losses due to this cause. The Cotton Insurance Association, of Georgia, has reported that 90 per cent of cotton fires in transportation are due to locomotive sparks. A grain dealers' mutual fire insurance company reports each year from 17 to 28 per cent of its losses due to the same cause.

The fire records of manufacturing risks which have been published in the Quarterlies of the National Fire Protection Association show a very material percentage of fires from locomotive sparks; and yet, taken as a whole, we would not consider manufacturing risks as particularly susceptible to the spark hazard. The record of fires in fifteen classes of manufacturing risks showed about 3 per cent to be due to this cause.

The Waste from Sparks. Exhaustive tests on locomotives have proved that 9 per cent of the available source of heat energy was lost through unconsumed fuel in the form of cinders or sparks passed out of the stack. Carefully prepared figures show this to be an equivalent of twenty million dollars or more today. From the results of tests made, it was concluded that this fuel loss in the form of cinders collecting in the front end and passing out of the stack, admittedly very large, may readily be reduced. The results there recorded were obtained with a boiler having a narrow fire-box; the losses in the form of cinders would probably be smaller with a wide fire-box. A sure road to improvement in this direction lies in the direction of increased grate area. Opportunities for incidental savings are to be found in improved flame ways, such as may be procured by the application of brick arches or other devices. Such losses may also be reduced by greater care in the selection of fuel and in the preparation of the fuel for the service in which it is used.

Drastic Preventive Regulations in Canada. The Canadian Government recently published the terms of a sweeping order made by the Board of Railway Commissioners affecting the Grand Trunk, Canadian Pacific, and the Canadian Northern Railways in British Columbia, prescribing regulations for the prevention of fires and regulating the operation of locomotives within that province. Every locomotive must be fully equipped with spark arresters of a specified size, with sheet iron dampers and overflow pipes; the railways must provide inspectors who must examine each locomotive at least once a week. The roads are prohibited from burning lignite coal without special permission from the Board; and between April and November, the burning of ties and other refuse alongside the tracks is forbidden. Any fire starting or burning within 300 feet of the railway track shall be presumed to have started from the railway. When the roads use oil-burning engines the Board may relieve them of such requirements as it sees fit. The regulations are the most drastic ever applied to any railroads on this continent and were made at the instance of the Dominion Forestry Association and the Dominion Forestry Reserves in order to bring about, in British Columbia, the speedy adoption of oil-burning locomotives exclusively.

OILY MATERIALS

Numerous fires occur from the spontaneous ignition of oily waste, oily clothing, finishing rags, etc., and it is evident that such materials should not be allowed to collect in out-of-the-way places. Plumbers are inclined to be careless with oily waste, usually dropping the waste where they have been working or throwing it under the work bench.

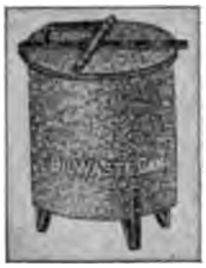
Fig. 328 Waste Can

Oily Waste. A sufficient number of standard waste cans, Fig. 328, should be provided and all oily waste should be placed in these cans during the day and removed from the building at night without fail. Clean waste should be stored in metal-lined bins. If preferred, standard cans may be hung from posts, provided they are arranged to be readily removed and to maintain a 4-inch clearance to wood posts. When waste is past its usefulness, it should be burned; and care should be used to keep it separate from sweepings or other refuse, owing to the extra hazard.

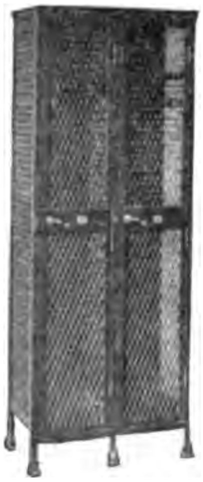
Fig. 329. Metal Clothes Locker

Sawdust. Sawdust is a dangerous incendiary, often used as a dampener on marble floors, to fill cuspidors, etc. It is also often used to soak up oil drippings in front of barrels. The least bit of oil, such as linseed, grease, oily rags, and the like, will bring on a rapid oxidation which will eventually cause spontaneous ignition of the sawdust. Sand is a desirable substitute for some of these uses.

Workmen's Clothes. Workmen's clothes should, where standard vaults are unavailable, preferably be hung in the open, away from inflammable material and where the air will circulate freely about them. Painters' overalls become oil-soaked and are very liable to cause trouble if rolled up and thrown about. In oil or grease risks they must not be allowed in wood closets; and if placed in iron closets, the latter should be of ventilated construction to allow air circulation and ready inspection. Never allow oily waste

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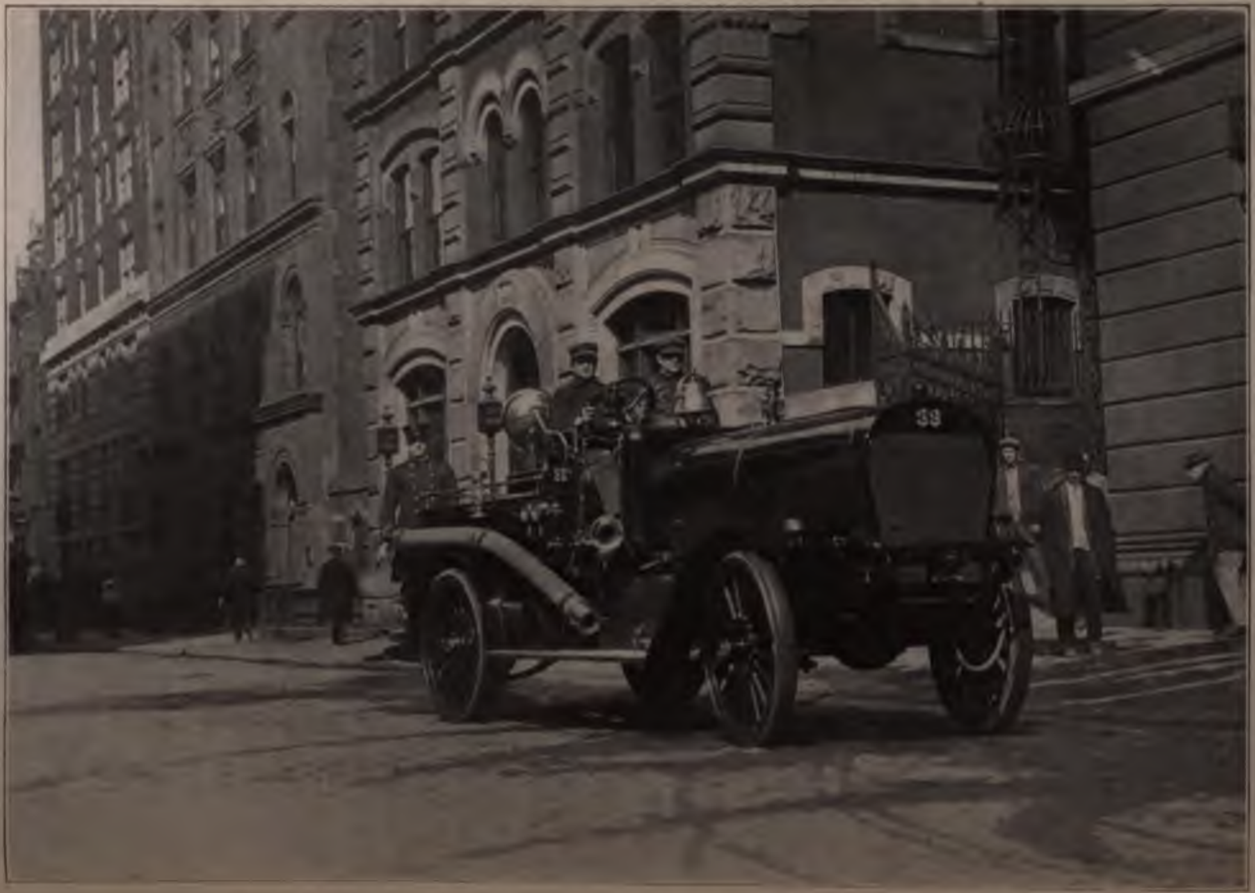
TILDEN FOUNDATIONS.



IMMENSE AUTO FIRE ENGINE OF THE NEW YORK CITY FIRE DEPARTMENT

This Is One of the Newest and Largest Engines in Which the Gasoline Motor Furnishes the Power for Driving the Car as Well as Pumping the Water to be put in these closets. Approved metal lockers should always be advocated, Fig. 329.

Floor Oils, Etc. Floor oils, with greater or less percentage of vegetable oil in the mixture, are being used very extensively in dwellings, halls, schools, etc. Mops, brushes, and cloths used in applying these should be hung up free from contact with any wood; or else they should be kept outside the building or in a fireproof vault inside the building. There are floor brushes which offer an element of danger, such as reservoir brushes, designed to use kerosene for laying dust when sweeping floors. There is also danger of gasoline being substituted.

Sweeping Compounds. Sweeping mixtures sold under various trade names used for laying dust vary considerably in respect to fire hazard. Linseed and other vegetable oils capable of producing spontaneous heating have been found in some of these preparations. Gasoline and kerosene have also been found in these preparations. The comparative hazards of most of these compounds can be found by consulting the List of "Gas, Oil, and Chemical Appliances."

Dust Cloths. Dustless mops and dust cloths made of fine cotton saturated with oil, offer a serious hazard. Some manufacturers seem to recognize this and offer silk cloths and especially prepared non-hazardous cloth which should be looked upon with serious skepticism.

Filings. In machine shops, iron and steel filings dropped to the floor become oil soaked and will cause combustion. Filings should be removed every evening and the broom or brush used in sweeping them up should be kept outside the building.

SMOKING

Little need be said concerning this very common, perfectly well-recognized, and most prevalent cause of fire. Tobacco is the most extensively used luxury on the face of the earth and its consumption is not confined to any particular class or nationality. People of all walks of life and of all races are addicted to its use, and the habit is growing in a manner that is astonishing. It is estimated that 21,718,448 cigars are burned in the United States every twenty-four hours, or 251 every second of the day and night the year around.

There are nearly 24 million cigarettes consumed every day, or nearly a million every hour, and over $60,000,000 a year are spent on this habit. Is it any wonder that smoking, combined with the careless use of matches, causes more fires today than any other one thing.

In factories using much inflammable stock, workmen should be compelled to use approved or safety matches only, to be supplied by the management, if necessary, to secure enforcement of this rule. Workmen should be instructed to take care of their pipes, and coats should not be left about. There is no objection to allowing smoking in boiler rooms during the noon hour; and in large works, or stores employing many men, special smoking rooms might be safely and advantageously arranged. The New York Bureau of Fire Prevention posted the following signs in buildings where the conditions make careless smoking and use of matches an eminent hazard: "Smoking prohibited in these premises under penalty of fine or imprisonment or both." The following sign is frequently found desirable: "Smoking prohibited by order of the Underwriters." No rules will eliminate the careless disposal of smokers' matches, glowing butts, flying embers from pipes, etc. Every student should be a self-appointed emissary for the purpose of reforming some well-known careless smoker, possibly himself. Cigarette smoking should be prohibited under all conditions within the premises of shops, department stores, etc. Numerous fires are caused by cigars and cigarettes falling upon window awnings. It is recommended that all such awnings be fireproofed, just as scenery in the theater is fireproofed. Cuspidors should be of metal. The use of wood boxes, especially when filled with sawdust, should never be allowed for this purpose.

MATCHES

Besides the numerous fires which are caused by matches, due directly to their careless disposition by thoughtless smokers, many fires are due to their general use and to the common and promiscuous manner in which they may be obtained. Children love to play with matches, and many precious lives are lost every year, due primarily to the criminal negligence of grown-ups. The parlor match, or snap match, which has been in such general use has become an abomination. These matches are frequently stepped on by women and their gowns ignited. Many tragedies have thus occurred. Fire-prevention engineers have long tried to legislate all kinds of strike-any-where matches out of existence and have strongly recommended the use of safety matches or those which strike only on specially prepared surfaces. The burning of property will continue, however, as long as there are matches of any sort that will light from friction with any kind of surface.

Hughes-Esch Bill. The Hughes-Esch bill, which was passed by Congress, will stop the manufacture of white phosphorous matches after July 1, 1913. In view of the increased temperature of the ignition point in matches made under its provisions—being not less than 300°F., produced by friction, as against 200° or less, for parlor matches—matches must be a greatly reduced fire hazard as compared with those of white phosphorus used in the past. The Diamond Match Company, who controlled a French patent for the manufacture of these matches, gave up their exclusive right to it, and any manufacturer can now produce the double-tip, non-poisonous, sesquisulphide of phosphorus, strike-any-where match.

Laboratory Tests. The Underwriters' Laboratories have recently completed tests of matches, and as a result are prepared to standardize and label such goods. The four types of protected matches which they are proposing to label are:

Type A, the strike-on-the-box match.
Type B, inert bulb, protected tip match.
Type C, single-dip, safeguarded head match.
Type D, inert bulb, ordinary tip match.

The report contains some interesting data as regards fire hazards of matches, and especially those arising from the throwing off of blazing particles which are responsible for most of the match accidents and fires. It states that the composition of the heads of Type A, as is common with strike-on-the-box matches, is of the explosive character likely to be accompanied by a fly hazard; while the composition of Types B, C, and D is non-explosive and practically free from any fly hazard. The results of the comparative tests of the fly hazard of samples of Types A, B, C, and D showed that Type A compares very favorably in this respect with representative foreign types of strike-on-the-box matches; and that Types B, C, and D possess no material fly hazard.

Fire Hazards. In respect to fire hazard, Types A, B, and C are safeguarded to as great an extent as is commercially practical under the present status of this industry: Type A is less hazardous than the ordinary class of strike-on-the-box matches, and Types A, B, and C are considerably less hazardous than the common strike-any-where type of matches, such as the "parlor". Type A, as made with strong approximately round splints, is in some respects a little less hazardous than Types B and C; while Type B is in some degree safer than Type C. Matches of this type do not strike readily on cloth or other soft, yielding substances, but ignite acceptably on an abrasive surface. It is claimed for them that their sticks are strong and made of white pine, and are not treated by chemicals which take the life out of the wood and weaken the match stick. It is important to note that this type of match will not ignite by side friction but must be struck on the tip. Matches of this class manufactured by the Diamond Match Company are to be approved and labeled. Type D is not from the fire insurance point of view satisfactorily safeguarded in respect to sensitiveness to ignition.

Foreign Safety Matches. Laboratory examination of the foreign safety matches showed them to be inferior to and more dangerous than the American product. Their principal hazard was in the splints. In a number of brands these were of poor quality and broke when the matches were struck, allowing lighted heads to fall. This probably was due to the weakening of the fiber by the chemical treatment of the sticks. A few of the foreign brands also showed sparking hazards.

Rats and Matches. It has long been customary to attribute the cause of many fires, which could not be otherwise accounted for, to the gnawing of matches by rats and mice. Nearly all fires which started in partitions or out of the way places were easily explained in this way. Edward Atchison, years ago, conducted experiments with living mice and matches which seemed to prove this theory plausible. Other investigators have been unable to prove the soundness of his theory and there have been many scoffers at the idea. There are authenticated cases, however, in which mice and rats have used matches in the building of their nests in which there might have been some incidental friction in the placing of the matches in their desired positions or in drawing them along to the desired locality. Such a hazard will be largely overcome by the adoption of the approved type of matches and safety matches. Tests recently conducted by the Laboratories seem to show conclusively that ingredients are used in the modern match composition whose odor, fumes, and taste, while not poisonous, are strongly obnoxious to rats and mice; indeed, rodents will starve to death before they will attempt to gnaw such chemical compounds. The results of cutting tests show that Types A, B, and C are safeguarded sufficiently in respect to ignition by friction to make it difficult for a rat or mouse to ignite the composition by gnawing.

UNCLEANLINESS, RUBBISH, AND SWEEPINGS

Good housekeeping, or general care and cleanliness, is the best, simplest, and easiest preventive against fires. It applies to all kinds and classes of property alike. The neglect of closets, corners, dark places, under stairs, etc., is as common in the dwelling as in the factory, mercantile property, or hall, school, or church.

Factory Conditions. There is no good reason for finding a manufacturing plant dirty and neglected. In some cases, it is the lack of help, which can be remedied; in others, the result of falling into a rut, which should be remedied; and still more often, it is a case of absolute neglect on the part of some one on the inside, and must be remedied in order to obtain safe conditions. An example of typical factory uncleanliness is shown in Fig. 330.

It is apparent also that a fire, starting from whatever cause it may, be it near the ceiling or on the floor, will spread much more rapidly if there is more or less light, fluffy material, than if the surfaces are kept clean. Such a minor matter as lint on the electric light drop is a feature that should have careful attention. There is a possibility of a short circuit always existing in the lint ready to spread the fire to dangerous points, like the fuse in a blast.

As a further evidence of the importance of cleanliness, in nine cases out of ten the product obtained in a clean mill is far more satisfactory than in a mill where the cleanliness is neglected, so that any effort put forth towards further cleanliness should be well rewarded by better products.

Remedies. Factories should be swept daily and the refuse at once removed and burned or temporarily stored in fireproof vault outside. This work should be done in a regular and systematic manner. In large plants it should be a special department, the same as a street department in a large city. Waste or refuse chutes, while convenient, are frequent causes of fire and are liable to cause trouble no matter how well constructed. The refuse should be placed in standard metal barrels and removed at once to the boiler room and burned; never should it be left in the factory over night. The large proportion of fires due to the improper accumulation of waste papers, sweepings, and rubbish shows the importance of this hazard. Every ton of paper represents a value of from ten to twenty dollars. Modern ingenuity has devised machines for baling paper

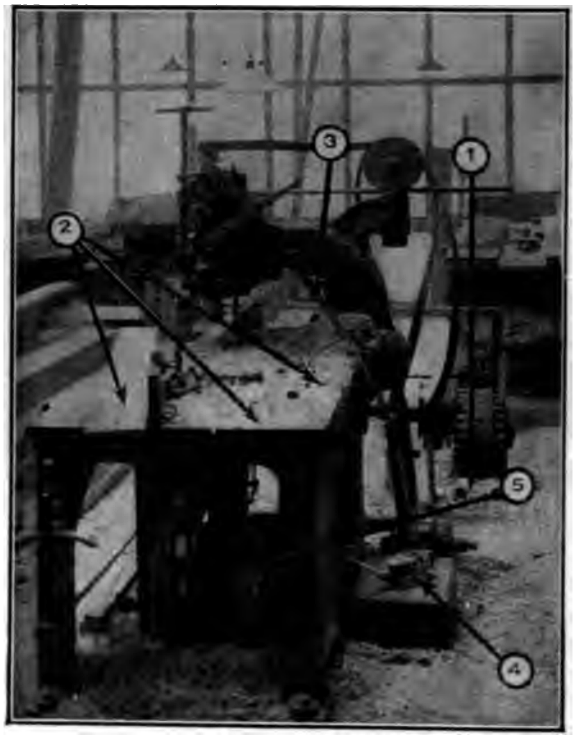


Fig. 330. Typical Factory Uncleanliness. 1. Shavings in Contact with Electrical Machinery; 2. Waste Material Allowed to Remain on and around Idle Machines; 3. Neglectful Handling of Equipment; 4. Oil Cans Left Where They May Be Tipped Over and Spilled; 5. Inflammable Liquids Stored in Out-of-the-Way Places in Contact with Shavings, Belts, and Oily Rags

regularly, so that it may be conveniently and economically cared for until sold. Thus practical utility can be combined with the reduction of hazard. The vacuum cleaning system is now effectively used in dwellings, halls, mercantile property, etc. Its forerunner is the dust-collecting suction-blower system found in woodworking plants. This system should be readily modified to fit any conditions and should find a far greater range of usefulness than it now enjoys. In the ordinary factory it is not uncommon to see under the elevator mechanism a dirty mess of grease and dust. This may be avoided easily and cheaply by suspending a shallow pan under the apparatus to catch the oily drip from the bearings and then cleaning the pan frequently. Where windows are below the level of sidewalks, and areas are constructed for the admission of light, the owners of the buildings should be careful to prevent the accumulation in such places of dried leaves, straw, or other combustible material, for a falling cigar or spark from a neighboring fire might easily ignite them.

Trash Burners. It is surprising how many merchants dispose of their rubbish by burning it loose on the ground or in receptacles which offer little protection against flying brands. A form of burner that has proved very practical and one of sufficient size to be adequate for several parties (this can be built at a nominal expense by clubbing) can be made as follows: A furnace is built of brick, stone, or concrete, about four by four by eight feet in dimensions. It has a door at one end, and the top is a sheet-iron lid on hinges. The chimney has a wire screen for arresting sparks. A grate is built inside some inches from the ground so as to allow a draft.

USE AND HAZARDS OF INFLAMMABLES, VOLATILES, AND EXPLOSIVES *

The use or storage of fluids giving off inflammable vapors at ordinary temperatures, even with all known precautions, is a danger which should always be recognized. Most of the fires caused by such materials are due to carelessness in the handling of the oil after it has been drawn. Dealers frequently draw the oil on order, then let the cans stand; or the faucets on barrels or tanks are not tightly closed. There will always be some spillage or leakage. The floors become oil soaked and are ready for some cigarette smoker or other careless person with a match to start a fire.

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*For details of Coal Tar and By-Products, Petroleum and By-Products, Miscellaneous Inflammable Products, and certain Explosives, the reader is referred to "Chemistry of Combustion."

Fig. 331 illustrates suggestions for inside oil rooms where they should be permitted only by consent of Underwriters having jurisdiction. Suggestions for location, protection, and proper maintenance of such rooms are given in Rules and Requirements pamphlet entitled "Uniform Requirements". These specifications are intended only for the small inside oil room designed for the storage and safe keeping of the daily supply of oils, paints, varnish, etc., and also for the storage of paint cans, or pots, and oil cans at night. The main supply of oils, varnish, paints, etc., must be kept outside the

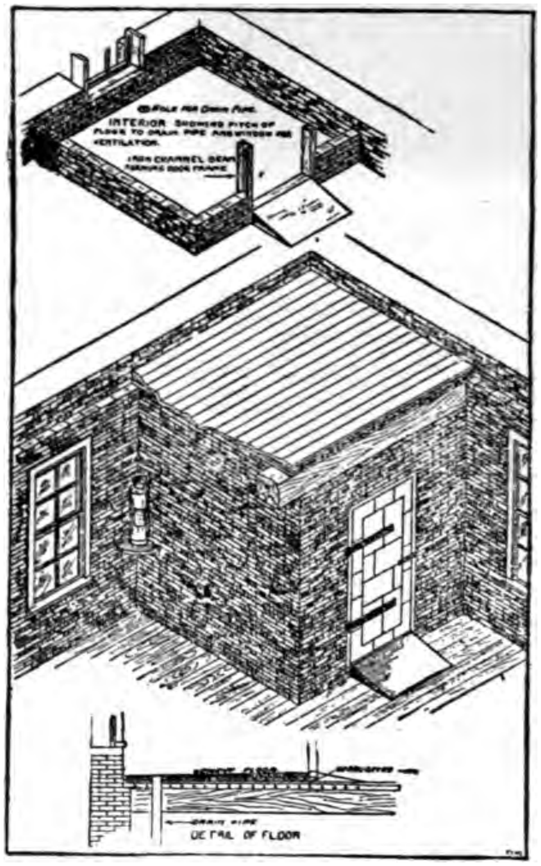
HOLE FOR DRAIN PIPE.
INTERIOR SHOWING PITCH OF FLOOR TO DRAIN PIPE
VENTILATION.
IRON CHANNEL BEAM FORMING DOOR FRAME
DRAIN PIPE
DETAIL OF FLOOR

Fig. 331. Standard Oil Room

main building or buildings. Gasoline, benzine, naphtha, or similar compounds, except in small quantities in approved safety cans, must not be stored in oil room or in factory.

Gasoline. The characteristics of gasoline have been previously mentioned, but the average man and woman still need to be suitably warned of its danger when used for simple domestic purposes. Gasoline should be used in open air wherever possible; but if it must be used in the house, all the windows should be opened wide and a sufficient draft created to drive all the vapor from the room. It is almost criminal to use gasoline in the kitchen or other rooms where it is exposed to fire. The vapor has been known to jump 30 feet from a tank in the open air and explode with such violence as to wreck the tank car and burn all the buildings in the immediate neighborhood. It is not necessary to touch a match to it. A spark from the heel of a shoe striking a tack or nail will explode the vapor. A lighted gas jet will produce the same result. Keep gasoline away from every kind of flame, even if that flame is enclosed, as in a stove or furnace. Articles dipped, washed, or soaked in gasoline give off an explosive vapor for hours after. They should be thoroughly aired before being used and always kept away from exposed flame. Frictional electricity generated by washing silks, etc., in gasoline will ignite the fluid.

Polishes. Several metal and stove polishes on the market contain quantities of benzine and other inflammables. Therefore, all polishes should be carefully investigated and only those allowed that can reasonably be called safe.

Alcohols. *Grain, or Ethyl, Alcohol.* Grain, or ethyl, alcohol is made principally from corn. Absolute alcohol gives off inflammable vapors at 51°F. Alcohol of 80 per cent strength gives off vapors at 68°F. and that of 50 per cent at 75¼°F. Vapors reach the final limit of inflammability when about 4 per cent. A solution containing but one per cent of alcohol will give off vapors containing 13 per cent, these vapors being both inflammable and explosive. The vapors are explosive between the limits of 4 and 13.6, this being an explosive range of 9.6, while benzine has a range of only 2.3. However, vapors of alcohol will not ignite from pure radiated heat and low temperatures, as gasoline does, but requires a temperature of 176°F. and an open flame or electric arc to be exploded. Alcohol above 95 per cent ignites readily when cold and above 60 per cent is more inflammable than kerosene. Since its flame is almost devoid of free carbon particles, it has very little heat-radiating power. Alcohol has the objectionable property of being very diffusible and will penetrate almost any substance except glass and metals. It also leaks readily when mixed with water. When spilled, alcohol evaporates very quickly. Owing to its ability to mix readily and in all proportions with water, it is far superior to most other volatiles. When diluted to one-half its strength it can not burn and will not spread fire as in the case of gasoline.

Wood, or Methyl, Alcohol. Wood, or methyl, alcohol is obtained from the destructive distillation of wood. Crude wood alcohol contains from 75 to 90 per cent real methyl alcohol and a large amount of acetone, an inflammable and explosive liquid about equal in danger to benzine. Wood alcohol vaporizes at a lower temperature, is more inflammable, and is in every way more dangerous than ethyl alcohol.

Denatured Alcohol. The Act of Congress which was passed June 7, 1906, provided for the withdrawal from bond, tax free, of domestic alcohol if rendered unfit for beverage or liquid medicinal uses by the admixture of denaturing materials. It is classed as completely denatured alcohol and specially denatured alcohol. There are two authorized formulas for completely denatured alcohol.

(1) One hundred parts by volume ef ethyl alcohol of not less than 90 per cent strength (180 degrees proof), two parts by volume of approved methyl alcohol, one-half of one part by volume of approved pyridine bases.

(2) One hundred parts by volume of ethyl alcohol of not less than 90 per cent strength, ten parts by volume of approved methyl alcohol, one-half of one part by volume of approved benzine.

This latter formula is the one generally used. It is the mixture advertised and sold for heating, lighting, power, cleaning, etc., under various trade names, such as Pyro, etc. Alcohol denatured in any other manner is classed as specially denatured alcohol and is used for industrial purposes in the various manufactures and arts in cases where completely denatured alcohol would be unsuitable for use.

Hazards. It is obvious that denatured alcohol should have the general characteristics and hazards of grain alcohol. It is equally obvious that the small amount of benzine added to it should have no effect on the hazard of the whole, and that denatured alcohol is preferable, from every point of view, to gasoline. The effect of the addition of wood alcohol is a somewhat mooted question, some holding that the hazard of denatured alcohol approaches that of wood alcohol. The author is inclined to hold that denatured alcohol can be considered in the same class as grain alcohol.

CONTAINERS FOR HAZARDOUS FLUIDS, STORAGE AND SUPPLY SYSTEMS

Certain systems when approved and labeled may be permitted for use when installed according to the Rules and Requirements, if not in violation of any state law or local ordinance, and *if the company insuring the property consents to the same in writing on its policy.* The List of Gas, Oil, and Chemical Appliances should be consulted. In every case be sure that the trade name together with the name and address of the manufacturer is marked on the device. In Class *B* the words *Long Distance* should appear. The use or storage of fluids giving off inflammable vapors at ordinary temperatures even with all known precautions is a danger which should always be recognized.

Class A Isolated Storage Systems. Systems which provide for storing and handling gasoline, naphtha, and similar fluids, outside of and so removed from adjoining property as not to create an exposure thereto, are considered from an insurance viewpoint as the least dangerous.

Class B Inside Discharge Systems. These systems, which introduce fluids giving off inflammable vapors inside of the building, are regarded from an insurance viewpoint as more dangerous than isolated storage systems. Particular attention is called to the rule requiring storage tanks used with these systems to be installed outside of and removed a proper distance from the building.

The different inside discharge systems are classified as to relative hazard as follows:

(1) Systems which have storage tank outside and located in an improved manner underground, and which will permit no hazardous fluid to be discharged inside the building by any derangement of the system.

(2) *Approved systems which have storage tank outside and underground; which will permit no more than one gallon of hazardous fluid to be discharged inside the building by any derangement of the system; and which use a suction pump feed.*

Inside Discharge System Pump. This device is considered suitably safeguarded only when installed with a properly screened vent pipe leading from the upper end of the cylinder to the outside of building, and when installed in conjunction with an outside tank constructed and installed in accordance with the Rules and Requirements.

Underground Storage Tanks. These devices are designed for the underground storage of hazardous fluids and are suitable for use in connection with Inside Discharge Systems, Isolated Storage Systems, Gasoline Engines, etc.

Portable Tanks. These devices are intended for filling automobile tanks in garages. They consist of metal tanks of approximately one barrel (50 to 60 gallons) capacity, mounted on wheels, and provided with a measuring pump. These tanks are substantially constructed and are provided with reliefs for abnormal pressures. A supply system which introduces hazardous fluids inside the building is regarded from an insurance viewpoint as a distinct increase in hazard, which should be recognized by Underwriters.

Stationary Tanks in Buildings. These devices are designed for the storage of paints, oils, varnish, turpentine, and linseed oil (not for storage of benzine or gasoline), and are considered as a decided improvement over the storage of such materials in wooden barrels, but can not be considered as entirely eliminating the hazard of storage of paints, oils, varnish, turpentine, and linseed oil in the building, and should not be used as a substitute for inside discharge systems having outside storage.

Explosives.* Explosives are subject to the local ordinances in any well-regulated city or town that has any regard for its civic welfare. The ordinances which have been prepared by the National Fire Protection Association and recommended by the National Board of Fire Underwriters should be studied and suggested where appropriate.

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*For details concerning the nature of certain explosives, the reader is referred to "Chemistry of Combustion", page 87.

MISCELLANEOUS HAZARDS

Electric Signs. The first rule to make signs safe is that they be constructed entirely of metal and that the wiring be done in accordance with the requirements of the National Electrical Code. Interior signs must be wired in accordance with the rules governing interior wiring, and outside signs must be wired in accordance with the rules governing exterior work. Signs, whether they be electric or otherwise, present two other hazards. A sign on the front of a building or on the roof may be a means of communicating fire from one building to another, and in some cases they help to destroy the protection that parapet walls afford. Another hazard is the interference they present to the fire department. The sign itself and the guide wires and cables will not only break streams of water, but will prevent the best use of ladders and other arrangements on which streams are carried to points above the ground.

Cloth Signs. The use of cloth advertising signs in front of stores, vacant buildings, and billboards is a decided fire hazard and a menace to life and to property. All such should be removed wherever they are in use. Every sincere fire prevention disciple should do all in his power to eradicate the use of this method of advertising in his city.

Billboards. These frequently offer a very serious hazard. When built of wood and to excessive height, they may contain a large amount of combustible material and often imperil the safety of adjacent buildings or even those across the street. The Chief of the Fire Department or some one of equal authority in a fire prevention bureau or fire marshal's office should pass upon these hazards. No billboard should be more than 10 feet in height, nor measure more than 10 feet from the eaves of any building with a pitched roof.

Fumigation. The burning of sulphur, or exposing fumes of the volatile carbon bisulphide, which is highly explosive in mixture with air, are distinct hazards. Various kinds of dips and washes for this purpose have benzine as a component part.

Use of Water. This is often the means of producing fire. It is directly so in the case of fire produced by quicklime. It is a necessary adjunct to spontaneous ignition of charcoal, fibrous substances, etc. In the storage of calcium carbide, water is its only danger. Other chemicals will react in a similar manner, conspicuous among which is sodium peroxide, a bleaching agent. Hydrogen peroxide is given off when water is added. Where there is chemical action there will be heat, hence the danger here.

Working Over Hours. Working over hours produces fires through the sleepy indifference of tired workmen. Fires have been discovered in a building which was burning briskly in the upper stories, while the workmen below knew nothing of it.

Seasonal Hazards. *Winter.* In thawing out frozen water pipes, heating apparatus is often forced to the point of danger.

Summer. Burning of brush, grass, and rubbish is dangerous.

Spring. Endeavors in house cleaning and repairing frequently lead to carelessness and conditions that cause fires.

Fall. Neglect to inspect stovepipes, flues, and heating apparatus for defects due to rust and idleness causes fires when the first cold spell arrives and heaters are started.

Fourth of July and Christmas. The cause of the horrors that have attended these festive occasions is too well known to be described in this volume. Everyone should supply himself with a large number of the bulletins issued by the National Fire Protection Association preceding each of these holidays, and supply the local papers, societies, churches, etc., where such warnings may become effective. Those engaged in the insurance business should furnish their clients with these bulletins.

Celebrations. Celebrations, with the spirit of freedom which prevails, with the use of inflammable decorations and tinsel, with the presence of fireworks, with the crowds of people, carefree and careless, smoking, and throwing countless lighted matches about, all offer a period of greatly increased hazard. Special precautions should be taken during such festivities.

Strikes. The enmity of dissatisfied or discharged hands, especially in seasons of strikes, sometimes leads to fires and is a danger which should be carefully considered. Employers who are constantly quarreling with their help are undesirable clients from the underwriting standpoint.

Hazard of Previous Fires. Frequently fires occur in premises in which fires have already broken out and caused more or less damage, after the original fire is presumably extinguished, due to smouldering embers, flying sparks, etc., being rekindled. Insufficient attention to extinguishment, a change or rise of wind, and lack of proper watchfulness and safeguards thereafter are the prominent factors which influence the starting of second ignition. Fires are frequently caused by electrical fixtures and wiring that have been deranged or damaged by previous fires in the same buildings. After every partial loss in a building in which electricity is used for light, heat, or power, all wiring and controlling devices should be carefully inspected by a competent person before the equipment is used again. The damage done by the lightning as a rule is very small (some boards may be splintered or roof torn away) unless the owner neglects immediately thereafter to inspect the building carefully at all points and guard it against an outbreak of fire.

Care and Maintenance. Aisles of ample width should be maintained to stairs, elevators, fire escapes, fire-wall openings, and between stock piles. Broken windows should be repaired immediately. Broken plastering, holes in floors, partitions, etc., allow fire to reach concealed spaces where it is hard to extinguish and they should be repaired without delay. Stock should be kept at least 18 inches below ceilings (and also under deck floors) in order to allow hose streams to be used effectively and also to permit of the spreading of tarpaulins. It should be placed on skids raising it at least 4 inches above the floor to minimize loss by water; and should be piled so as not to interfere with the operation of fire doors; when necessary, guards will be required.

Endemic Carelessness. It has been said that Americans take the lead for being the most careless people on earth, and until public opinion is educated up to a point where it will rise in its might and demand that each be careful, especially where carelessness may result in loss to others, we shall continue to lead the world in the lives lost and the property destroyed by easily preventable causes. The use of the medical term "endemic," as applied to carelessness, admirably describes the present condition of the American people. An endemic disease is one which is constantly present to a greater or less degree in any place, as distinguished from an epidemic disease which prevails widely at some one time, or periodically, and from a sporadic disease of which now and then there occur a few instances.

HOW TO INSPECT MANUFACTURING OR SPECIAL HAZARD RISKS

The operation of mechanical forces and the handling of chemical combinations obviously involve a greater fire hazard than does the simple storage of inert substances in warehouses. There is no process of manufacture of any kind, involving motion or the use of heat or depending upon the principles of chemical combinations, which is not dangerous to a greater or less degree.

Therefore, it behooves every fire-protection engineer and inspector to recognize the hazards involved in the various processes and conditions which are incident to industrial and commercial life. He should be ready to advise methods which would tend to prevent fires, and by so doing he may frequently suggest economies in manufacturing operations that would save the manufacturer unnecessary expense. To do this he must keep pace with discoveries in mechanics, chemistry, and applied sciences.

A very large percentage of almost every class of manufacture has a few specially hazardous processes which involve a very small proportion of the whole, both in space and in value, but which endanger the whole by their hazardous location or arrangement. It is possible so to arrange a plant by reasonable foresight and proper regard for hazards involved, that these will be completely isolated from the main plant, either by judicious division walls or by complete segregation. By so doing, a fire originating in such a special hazard would be confined to a comparatively small value; and its burning would not endanger the larger values.

The inspector must have in mind at all times the danger of chemical combinations, not merely in the manufacturing processes involved, but in the storehouses connected with it. There are numerous chemicals which are harmless themselves, but if mixed together through an accidental breakage of their packages, or allowed to combine with comparatively harmless organic substances, such as sugar, flour and sawdust, would inevitably cause a fire or serious explosion. Such combinations may readily be brought about through the efforts of firemen in extinguishing a fire, the distributing force of the streams causing inextinguishable combinations of substances supposed to be properly separated.

Another source of danger is the presence of fine dust, such as flour, coal dust, fine sawdust, or even cement. Dust explosions have caused many disasters and serious losses in buildings, and the methods of taking care of such dangers should be very carefully investigated.

A manufacturing process that uses any inflammable material, as raw stock, or that involves its use in the plant, naturally invites a hazardous condition. Typical examples are the textile industries and woodworking industries. The location and storage of raw stock and the methods of arrangement in the factory are very important. Many processes demonstrate the hazard in an obvious manner even to the most inexperienced, and common sense suggests many suitable remedial measures. The use of oils and volatiles in many different kinds of processes produces hazards that are self-evident. All processes of heating and drying, all of which make use of these hazardous substances, need to be carefully investigated.

The following brief summaries are but suggestions to the inspector. The enumeration of the principal processes should lead an inquisitive mind to grasp the main essentials, and by means of the ensuing paragraph on hazards in each case, those features that offer a potential hazard may be noted and the methods of protection reported. Many factories of a given class may not possess all the processes assigned to that class. The raw stock may be partially worked up or certain digressions from the usual routine may be made. In most cases, the summaries contain suggestions for all the processes and hazards commonly found in each class. As the fire-protection engineer gains practical experience in the field of factory inspection work, he will readily observe differences and innovations in the usual routine of manufacture. He will investigate these carefully, and instinctively analyze each process or material in his mind to determine the fire hazards involved. In such cases, care and thought should be exercised to see that the hazard is not magnified as well as underestimated, and that the suggested improvements and protection are both rational and effective.

In compiling the following summaries, the author is greatly indebted to help derived from the published fire records and special hazard reports of the National Fire Protection Association and to the Crosby-Fiske "Hand Book of Fire Protection."

BAKERY AND CRACKER FACTORIES

Processes. Sifting, mixing, baking, cooling, frosting, frying, gluing.

Hazards. *Bake ovens:* kind—portable ovens, bread ovens, rotary ovens; arrangement of furnaces; combustible material nearby; fuel used; empty barrels and boxes allowed to accumulate in front of furnaces. *Cooling* before placing in bins or barrels. *Frosting kettles*, how heated and floor protection. *Frying*, arrangement of lard pans; methods of heating; protection on floor and surrounding woodwork. *Glue pots*, how heated and arranged.

Special Precautions. Proximity of combustible material to ovens. Arrangement of frying pans.

BLEACH, DYE, PRINT, AND FINISHING WORKS

Processes. Sewing, singeing, bleaching, dyeing, mercerizing, printing, etching copper plates.

Hazards. *Singeing:* open fire; hot plates; open gas flames; location and construction of room; cut off; method of heating. *Bleaching chemicals*, where stored; lime, sodium peroxide used or any of the chlorates used. *Dyeing*, general methods used. *Indigo dyeing*, care of lime and zinc dust. *Turkey-red dyeing*, construction of ageing machine and dry rooms. *Aniline-black dyeing*, chlorates used; oxidizing rooms free from lint. *Chlorates* used for oxidizing. Location of *cloth dry rooms;* method of cleaning rollers. *Etching*, use of nitric acid.

Special Precautions. Fire in cloth after leaving singeing machines. Use and storage of chlorate of potash. Spontaneous ignition of dyed goods, especially aniline blacks, after drying or ageing.

BREWERIES

Processes. Screening, steeping, malting (Old Style Floor System, Saladin Pneumatic System, Galland-Henning Drum System, Tilden System), rice or corn grit cooking, kiln drying, elevating, screening, grinding, mashing, boiling, cooling, fermenting, ageing, clarifying, racking, bottling, pitching, coopering.

Hazards. *Receiving separator* or screener: dust blown outside; magnets installed. *Malt houses:* care of ventilating fans. *Pressure rice cookers:* type; where located; reducing valve; safety valve and gauge; man on duty at all times while tank in use. *Malt kilns:* type; where located; how constructed; how heated; fuel cut off. *Malt roasters:* type; fuel; malt cooled thoroughly before placing in bins. *Grain dryers:* system; cut off; any woodwork nearby. *Elevators*, usual hazards of friction in boot and head. *Malt mills:* location; construction; magnets over rollers; relief covers; grain cleaned before reaching mill conveyors, wood or iron. *Varnishing vats:* varnish or shellac used; tanks how dried. *Peg pitching:* where done; type of machine; building well detached or cut off; fireproof construction. *Recoopering*, see Cooperage Factory Hazards. *Branding:* where done; irons how heated. *Ice machine*, ammonia or brine system.

Special Precautions. Barrel pitching should be well detached or cut off and room of fire-resistive construction. Malt mills should preferably be made of iron; have iron relief covers; be provided with magnets and have dust arresters.

BRICK AND CLAY WORKS

Processes. Mixing and tempering, moulding, forming or recompressing, drying, burning, preparing pigments and decorating, packing.

Hazards. *Drying:* method; arrangement and location. *Kilns:* construction and arrangement; fuel used. *Flues*, combustible material nearby. *Carriages* or gigs and racks of iron. *Forming machines:* kind of oil used; mixing; storage. *Preparation of decorating pigments*, any volatile solvents used. *Packing material:* where stored; how cared for.

Special Precautions. Prevention of contact or serious exposure of woodwork or other combustibles to the devices generating heat and to the heated air emanating from same by radiation, or the direct flow of such heat vertically or horizontally.

CANDY FACTORIES

Processes. Melting, batch warming, cooking and boiling, coating and tumbling, corn popping and nut roasting, crystallizing, dipping, shellacing, moulding, starch reclaiming, drying.

Hazards. *Melting and cooking kettles* and furnaces: location; construction; flues; fuel used; floor protection. *Batch warmers* or steam tables: location; method of heating; clear of woodwork; kept clean. *Coaters and tumblers*, gas or steam heated. *Corn poppers* and *nut roasters:* location; method of heating. *Shellacing*, use of alcohol and amount stored. *Dusters or sifters:* location; arrangement of "starchbuck". *Starch dry room:* location; method of heating; cleanliness; ventilation; and freedom from·dust; explosion hazard.

Special Precautions. Protection against dust explosion hazard. Construction and arrangement of cooking furnaces.

CARPET YARN AND WEAVE MILLS

Processes. Picking, carding, dusting and willowing, garneting, spinning, weaving, finishing, drying.

Hazards. *Sparks or spontaneous ignition* in raw stock, waste, and dyed yarn. *Picking*, foreign substance and friction. *Carding*, foreign substance and friction. *Dusting and willowing*, foreign substance and friction. *Drying:* arrangement of steam pipes; hot bearings; inflammable stock and lint. *Garneting and spinning*, friction. *Weaving:* friction; open flame in contact with Jacquard harness. *Finishing*, arrangement of nappers.

Special Precautions. Picking, carding, handling of stock.

CLOTHING FACTORIES

Processes. Storage and handling of stock, shrinking, laying out patterns, cutting, making, pressing, inspecting, storage and handling of waste cuttings or clippings.

Hazards. *Stock fires* either in baled goods or spontaneous ignition of dyed stock. Spontaneous ignition of *cutting board scrapings* or linseed oil rags. Spontaneous ignition of *waste cuttings*. Electric, gas, gasoline, coal, or charcoal stove-heated *sad irons*. Location and construction of *waste chute*. *Benzine* used for cleaning.

Special Precautions. Gas or electric heated sad irons left turned on. Accumulation of waste material under benches and around shafting.

COOPERAGE FACTORIES

Processes. Working raw material by sawing, bolting, steaming; equalizing, sawing, cutting, planing, crozing, chamfering and packing staves; making heads; cutting or sawing hoops; conveying, storage, and disposal of waste; seasoning and drying; coopering.

Hazards. *Dry kilns:* location; type; construction; method of heating; protection. Storage and handling of *shavings and refuse.* Location, kind, and method of heating *barrel dryers* and crisets; fireplaces.

Special Precautions. Dry kilns and shavings vaults.

CORDAGE AND TWINE WORKS

Processes. Opening, scutching, picking, batching, softening, oiling, breaking or combing, preparing (spreading, drawing, finishing), spinning (jennies or frames), twisting (machine or rope walk), sizing, drying and polishing or tarring, winding.

Hazards. *Stock,* kind and where stored. *Pickers or breakers,* where located. *Oils:* kind used; method of feeding to machine; quantity on hand; where stored. *Waste:* dust and flyings; care and disposition. *Tarring:* in main or detached building; how heated; main supply how stored. *Dryers:* where located; how heated and arranged.

Special Precautions. Foreign material or hot bearings in openers and pickers. Breakers and spreaders. Storage of jute stock.

COTTON MILLS

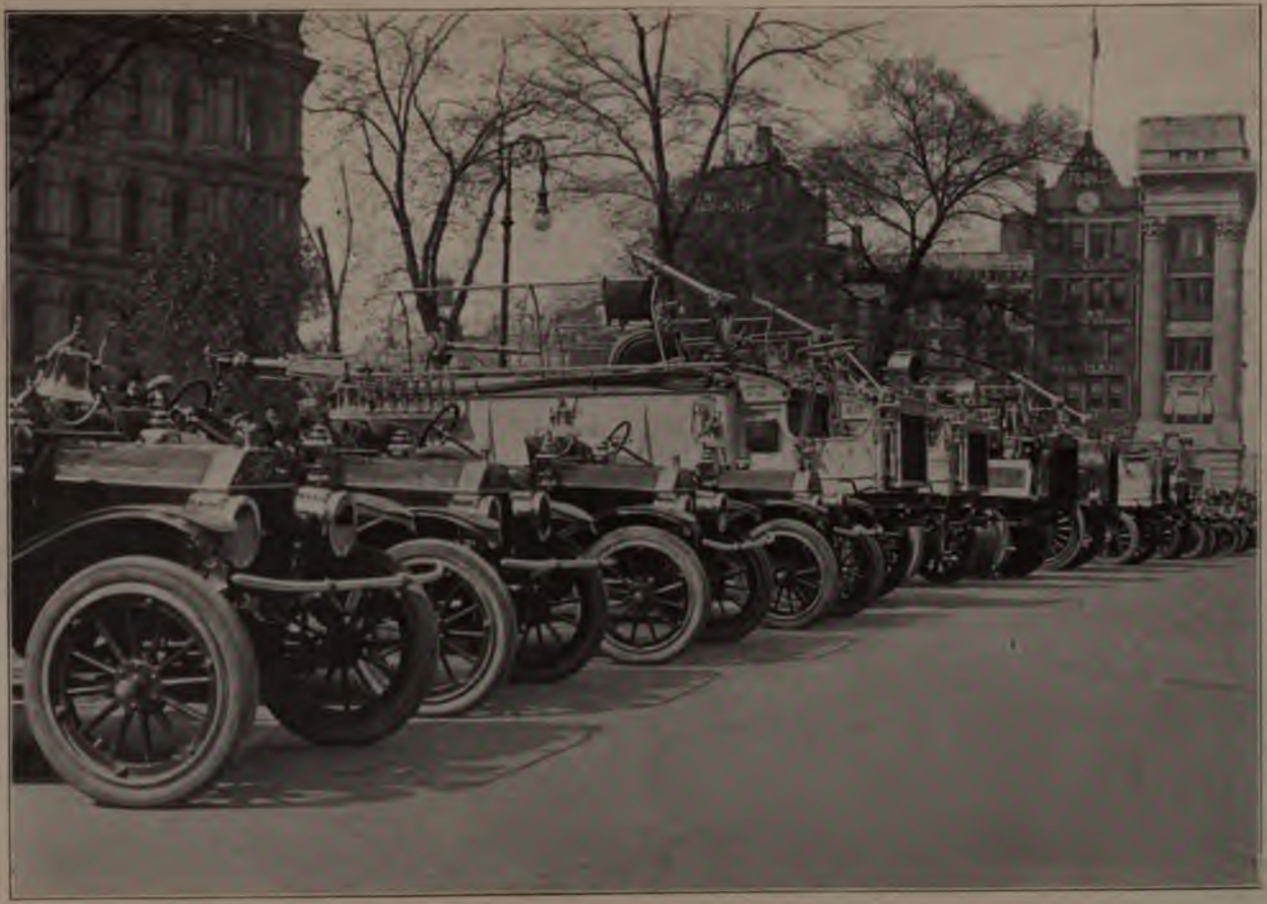
Processes. Storage, opening, batching, picking, carding, drawing slubbing, spreading, spinning, weaving, napping, drying, finishing.

Hazards. Location and construction of *storage warehouse,* standard warehouse, method of storing. *Cotton,* where opened and amount opened at once. *Opening:* hand or machine; where located; cut off; lighting; cotton how conveyed to picker room. *Breakers and lappers* (picking): where located; cut off; lighting; picker trunks protected. *Dust room,* location. *Stock conveyors:* between what rooms or buildings; location of blower and method of stopping; automatic devices or dampers; stock fed direct from machine or into hopper by hand. *Card room:* location; lighting. *Napping:* location; dust, how conveyed away and where. *Dryers:* type; method of heating. *Waste,* where stored. *Matches,* use prohibited or limited by employees.

Special Precautions. Openers or pickers, fire caused by foreign material in stock. Open lights or electric short circuits in picker and card rooms where accumulations of cotton fly. Stock conveyors cause fire due to friction or sparks, and fire may be blown from one building to another.

COTTON-SEED OIL MILLS

Processes. Cleaning, linting, handling hulls, heating, pressing, handling oil, press cake grinding.



NEW YORK CITY'S MODERN FIRE-FIGHTING APPARATUS

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Hazards. *Cleaning machines:* location; dust blown where; blower separator. *Linters:* sand screen and magnets before reaching linters; condensers and feeders; construction; cut off; accumulation of lint and dust; lint baled where. *Hull house:* how are seeds conveyed to hull house; crushers. Heaters, steam. *Oil:* how conveyed to storage tanks; location of tanks. *Press cloths:* material; dried how and where; stored after drying. *Cake grinding:* location of mill; type. *Hulls,* conveyed to boiler for fuel.

Special Precautions. Accumulations of lint and dust in cleaning and linter rooms, and sparks at linter due to foreign material.

DEPARTMENT STORES

Processes. Receiving and unpacking of goods, storage, general retailing, altering and repairing clothes, touching up furniture, upholstering, storing furs, kitchen and restaurant, packing and shipping, general repair, carpentry and electrical work.

Hazards. *Disposal of waste paper* and wrapping material. *Waste chute,* vaults or bins. General utility and *repair department* hazards. *Kitchen stove,* candy kettle, etc. Disposition of *cleaning, rubbing, and polishing rags* in furniture department. Arrangement and type of *sad irons* in clothing department. Occasional *bronzing* with inflammable mixture.

Special Precautions. Waste paper hazard.

DRUG HOUSES

Processes. Preparing laboratory work, mixing, compounding, boiling, extracting, bottling, labeling, packing.

Hazards. *Compounding:* use of heat or stoves; boiling or cooking of inflammable compounds; gas stoves. *Storage and handling of chemicals:* amounts and where stored; nitrates, chlorates, peroxide of sodium, metallic sodium or potassium, anodyne, picric acid, carbon disulphide, ether, alcohol, phosphorus, collodion, amylacetate or acetone, nitro-benzol, benzine, naphtha, gasoline, benzene, or benzol.

Special Precautions. Compounding and boiling over, or igniting of inflammable compounds being heated on coal or gas stoves.

FERTILIZER FACTORIES

Processes. Sulphuric acid manufacturing, storing raw material, crushing, grinding, screening, mixing, drying, bagging.

Hazards. Acid manufacturing. *Burners:* fines or lump; where located; construction and arrangement; method and frequency of firing up. *Nitre ovens,* arrangement and location. *Nitre,* where stored. *Bags:* where stored; washed after using; burned up. Location and arrangement of *Glover and Gay-Lussac towers* and *chambers.* Kind of *stock used:* especially fish scrap, tankage, etc.; where stored; kept dry; and quantity in one pile limited. *Rock drying sheds:* location; how heated.

Special Precautions. Pyrite burners, especially when firing up. Storage of scrap stock which is liable to spontaneous ignition and also nitre bags.

FLOUR AND CEREAL MILLS

Processes. Cleaning (separators, scourers, or smutters, and aspirators), grinding, sifting, purifying, bran dusting, rough grinding of corn, etc., conveying and elevating, drying, grain bleaching, flour bleaching, ageing, eliminating the Mediterranean Flour Moth.

Hazards. *Cleaning machinery,* provided with dust collector and disposition of dust. *Grinding machinery,* bearings well arranged and cared for. *Bran dusting,* also friction hazard. *Dust explosion hazard:* methods of collecting; arrangement and disposition of dust. *Buhr and attrition mills* for feed grinding, provided with magnetic separator. *Conveyor system:* drag, screw, pan, pneumatic or belt. *Elevators,* arrangement of boots and legs. *Grain dryers:* type and arrangement; blowers; forced draft; steam pipes. *Ageing,* location of electric ozone machine. *Grain bleachers,* arrangement of sulphur furnace. *General cleanliness* and conditions which induce spontaneous ignition. Method of *killing insects.*

Special Precautions. Cleaning machinery; journals and elevators; arrangement and construction of boots and legs; method of lubrication; journal alarms; wood or metal pulleys; rubber or leather belts; spontaneous ignition; dust explosions.

FOUNDRIES, BRASS AND IRON

Processes. Preparing moulds, baking cores, melting by cupolas, reverberatory furnaces or crucible furnaces, pouring, cleaning, finishing.

Hazards. *Drying stoves* for moulding sand, how arranged. *Core ovens:* where located; how arranged and heated; fired from outside. *Cupola furnaces:* roofs nearby covered with combustible material; fireproof firing floor; combustible material near cupola. *Brass crucible furnaces:* location and construction; floor non-combustible; combustible material nearby. *Flasks:* wood or metal; where stored after using. *Charcoal,* where stored.

Special Precautions. Protection of surrounding roofs against sparks from cupola furnace. Metal firing floor essential.

GARAGES

Processes. Handling, storing, cleaning, and filling oil or acetylene lamps, repairing, cleaning, storage of volatile oils, filling auto tanks with gasoline.

Hazards. *Kinds of machines,* electric, gasoline, steam. *Extinguishment of lights* on entering. Methods and location of *starting up steam machines. Calcium carbide,* location and quantity. *Removing and renewing carbide:* disposition of waste carbide. Location of *Prest-O-Lite tanks* in storage. *Gasoline removed* from machines previous to repair work. Location of *motor testing.* Use of *extension electric wires. Gasoline used inside* for cleaning. Size and location of *gasoline storage tanks;* pump, gravity, or pressure feeds. Methods of *filling gasoline tanks* on machines. Size, location, and construction of *repair pits.*

Special Precautions. Almost universal practice of cleaning or washing automobile parts inside of garage with gasoline.

Violations of good and safe practice of storing and handling gasoline.

Filling auto tanks with gasoline inside of garage, especially at night with auto lamps lighted.

Absolutely no smoking in garages.

Elimination of repair pits.

GLASS WORKS

Processes. Grinding, mixing, melting, casting, blowing, tempering or annealing, grinding of rough plate, polishing, preparing grinding material, decorating, packing and shipping, pot making.

Hazards. *Storage of charcoal* and disposition of *nitre bags*. *Melting furnaces, annealing ovens or lehrs, blow furnaces, glory holes, flattening ovens, hot furnaces*, and *range ovens*, all have similar hazards. Note location, construction, arrangement, combustible material at safe distance, fuel used, oil heating systems. *Dryers:* sand or emery; construction; method of heating. *Storage of hot blow pipes* after each run. Packing, storage, and methods of handling *packing material*.

Special Precautions. Defective furnaces with woodwork nearby. Open lights in proximity to loose packing material.

GLUCOSE AND STARCH WORKS

Processes. Elevating, cleaning, drying, grinding, converting, drying and grinding gluten; manufacturing corn oil; coopering.

Hazards. *Elevators:* wooden or metal legs; self-cleaning tops, arrangement of chutes and spouts. *Drying:* arrangement of dry rooms; liability to dust explosion. *Grinding starch*, liability to dust explosion. *Converting:* process used; any nitric acid used. *Drying and grinding gluten:* type of machines used; location. *Corn oil manufacturing*, process used. *Char kilns*, arrangement of same and handling of bone black or charcoal. *Sulphur burning:* arrangement of burners; storage of sulphur. *Coopering:* box or bag making; where done.

Special Precautions. Starch grinders. Dryers. Char kilns.

GRAIN ELEVATORS

Processes. Cleaning or separating, clipping, smutting or scouring, bleaching, drying or conditioning, elevating, mixing or grading, weighing and storing.

Hazards. *Elevators and conveyors*, due to friction in leg or boot. *Cleaning machines*, type and arrangement of dust collectors. Location of *dust room;* liability of *dust explosion*. *Drying*, arranging and construction of dryers and method of heating. *Bleaching*, arrangement of sulphur furnace. Liability of *spontaneous ignition*. *Smut machines*, frequently cleaned out. Sparks from *cob pit*. Method of *killing insects:* carbon bisulphide or other volatile and inflammable material; subjection to cold air; use of hydrocyanic acid gas, or of other means.

Special Precautions. Automatic journal alarm system for elevator and conveyor bearings; scrupulous cleanliness and methods to avoid accumulation of dust, which may be violently exploded by hot bearings, open lights, or other forms of fire; also to guard against spontaneous ignition.

GYPSUM PLASTER MILLS

Processes. Breaking, drying, crushing or cracking, grinding, bolting and screening, sand drying and grinding, cooking or calcining, cooling, mixing, bagging or barreling, storing.

Hazards. *Rock dryers*, proximity to woodwork or detached. *Grinding mill conveyors:* elevators and casings, wood or iron; combustible or fire-resistive storage bins. Protection of woodwork from *sand dryers;* hot sand conveyed and elevated in wooden or metal conveyors or elevators, stored in combustible or fire-resistive bins. *Cooker or calcining kettles* constructed and located to avoid possible overheating or ignition of exposed woodwork. *Cooling pit* for cooker.

Special Precautions. Cooling pit should be of fire-resistive construction, expose no woodwork, and have casings of conveyors and elevators to a fireproof storage bin made of iron. Careless transferring of hot flour through wooden devices to wooden storage bins causes most fires in this class.

KNITTING MILLS (Full Process)

Processes. Picking, carding, spinning, knitting, napping, brushing, board drying, washing and dyeing stock, stock drying, cutting and finishing.

Hazards. *Pickers*, location and class of stock used. *Stock oil*, kind used. *Cards*, open or closed; stock used and previously picked or lapped; quantity and care of fly. *Blower systems for conveying*, arrangement and safeguards. *Dryers*, board, hurricane, etc. *Dry rooms*, how heated and arrangement of steam pipes.

Special Precautions. Low grade stock and insufficient working in the picker room, causing fires at first breaker cards.

METAL WORKERS

Processes. Forge work, cutting, stamping, rolling, drawing, pickling, machine work, soldering, brazing, annealing, hardening, tempering, plating, enameling, tinning, japanning, painting, varnishing, lacquering, polishing, buffing, cleaning, pattern making.

Hazards. *Forges:* arrangement of fuels and kind of fuel; construction of floor and roof. *Fuel oil,* how stored and system of use. *Acids,* where stored. *Oils,* where stored. *Oily steel chips*, how cared for. *Hardening and tempering methods:* location and construction of room; arrangement for heating oil. *Enameling and tinning furnaces:* location; construction; arrangement of flues and fuel used. *Japanning, painting, varnishing and lacquering:* where used; amount in factory and main supply, where stored. *Dip tanks:* provided with automatic covers; overflow pipe, open lights excluded and others protected; location; construction and protection. *Japan and lacquer ovens:* location; construction; method of heating and ventilating. *Buffing:* blower system for handling; care of dust and where deposited; polish used on cotton wheels. *Benzine:* used for cleaning parts; used from safety cans; main supply and quantity, where stored. *Pattern making:* care of sawdust and waste; location and arrangement of dry kilns. *Glue pots*, how heated. *Oily waste:* how cared for; waste cans provided and emptied daily. *Sawdust* used to soak up oil.

Soldering, brazing, annealing and hardening furnaces, and mufflers: location; construction; operation; flues; fuel.

Special Precautions. Use and arrangement of mufflers, annealing and hardening furnaces. Defective construction, careless operation or combustible material nearby. Dip tanks and ovens. Handling of volatile and inflammable material; danger of ignition, overheating of ovens, etc. Spontaneous ignition of oily waste or buffing dust. Methods of handling and care are important. All of these processes, as well as oil tempering, should be done in fire-resistive rooms or segregated from main plant.

OILCLOTH AND LINOLEUM WORKS

Processes. Cork drying and grinding, linseed oil boiling, oxidizing, making cement, mixing, coating or printing, backing, drying, seasoning.

Hazards. *Cork grinding:* where done; dust how collected and cared for. *Linseed oil boiling,* located away from all combustible property. *Paints, varnishes* and volatile thinners: storage; use. *Compound mixing:* where done, main supply where stored; thinners used. *Coating machines:* where located; knives grounded to carry off static electricity. *Drying:* location; construction and arrangement of dry rooms and method of heating.

Special Precautions. Preparation of cork. Boiling oils and varnishes. Proper grounding of spreader knives.

PACKING HOUSES

Processes. Killing, cutting, salting, packing pork, lard and sausage making, fertilizer making, smoking hams, cooperage work, boxing.

Hazards. *Cooperage:* location; barrel furnaces or stoves; dry rooms. *Rendering:* location of lard department; cut off; steam heat used. *Waste and fertilizer tanks or dryers:* location; type; fuel; construction. *Smoke houses:* location; construction; cut off; grid over fires; combustible rods or hangers; accumulation of soot, cleaned out frequently. *Branding irons,* how heated. *Printing or marking ink:* where mixed; materials used. *Soldering irons:* where used; how heated.

Special Precautions. Cooperage department. Burning out of smoke houses due to ignition of soot, or fat or grease dropping on fire. Ordinary causes make serious fires due to presence of grease and oil in large quantities.

PAPER MILLS

Processes. Stock storage, opening, thrashing, sorting, shredding, cutting, .whipping, dusting, rotary bleaching, heating, finishing in Jordan engine, loading, sizing, coloring, making, cylinder or Foundrinier machines, loft drying, printing.

Hazards. *Stock:* where stored; especially rag stock, jute and rope waste; paper waste stock, etc. *Sorting,* dirt removed by hand or blower system. *Thrashers, willowers,* and *dusters:* where located; machines enclosed; provided with magnets; blower system. *Cutters:* location; cut off; blower system. *Rotaries or cookers:* steam pipes free from combustible material; insured against explosion. *Lime:* where stored; amount. *Machine room:* care of bearings; handling of "broke" or waste paper; care of fan bearings in steam hood. *Drying:* where done; steam pipes properly arranged. *Sizing kettles,* how heated. *Sealing wax,* how heated.

Special Precautions. Storage of rag and waste stock. Spontaneous ignition liable. Location and handling of dust hazard. Care of bearings.

PATENT AND ENAMEL LEATHER WORK

Processes. Tacking, coating, or daubing, drying, stoning, japanning, baking, sun drying, trimming, daub mixing, japan boiling, etc.

Hazards. *Preparation of daub,* japans, varnishes, etc. *Storage of linseed oil* and lampblack. Location and construction of *boiling room* or house; method of firing and handling; thinning. *Coating:* maximum amount of daub, etc., in room; method of handling. *Drying and baking:* location, construction, and arrangement of ovens; temperature; method of heating and arrangement. Storage, handling and care of *naphtha.*

Special Precautions. Direct heat or open flame should never be used in rooms where coating material is mixed or applied. Electric lights should be keyless sockets with double enclosed globes, and switches, etc., located outside.

PRINTING, BINDING, AND LITHOGRAPHING

Processes. Typesetting, stereotyping, electrotyping, photo-engraving, printing, gathering, pasting, sewing, gilding, binding, decorating, lithographing, varnishing labels, etc., mixing printers' ink, storage.

Hazards. Kind of gas used in *linotype machines. Stereotype and electrotype furnaces:* arrangement and method of heating. Amount of *collodion in photo-engraving* department. *Presses,* nature and protection of floor. *Type or rollers:* how cleaned; material used; benzine substitutes. *Benzine:* where used; amount in plant; safety cans used; main supply where stored. *Hand or finishing tools,* how heated. *Embossing machines,* how heated. *Glue pots,* how heated. *Varnishing:* where done; material used; quantity in room; main supply where stored; how applied; dryers. *Printers' ink mixed:* storage of linseed oil and lampblack. *Oily waste:* care; waste cans; burned nights. *Waste paper,* how cared for.

Special Precautions. Care and disposition of oily waste and rags, and of waste paper. Carelessness in the handling of benzine. Varnishing of labels, etc., not done in all lithographing plants.

PULP MILLS

Processes. Mechanical: cutting, barking, grinding, screening, cylinder wet machine making. Sulphite: cutting, barking, chipping, screening, digesting by "quick cook" or "slow cook," washing, bleaching, cylinder wet machine making. Soda: cutting, barking, chipping, dusting, digesting, washing, screening, bleaching, heating, cylinder wet machine making, concentrating soda liquor, recovering blach ash.

Hazards. Mechanical: *care of hot bearings,* handling of *refuse.* Sulphite: *chippers,* kept clean; chip conveyor from machine to bins top of digester house. *Lime,* where stored, kept dry. *Sulphur burners,* how built; cut off or detached; room fireproof, main supply sulphur, where stored. *Digesters,* where located; insured against explosion; steam pipes free from combustible material. Soda: same as sulphite except *sulphur burning* replaced by "black ash" recovery. *Black ash furnaces*, where located; cut off or detached; fireproof room; stack free from combustible material.

Special Precautions. Care of ventilator fans. Arrangement of chip conveyors. Operation of black ash furnaces.

RICE MILLS

Processes. Separating chaff from grain, hulling, whitening (by passing through the brush), handling chaff and bran polishing and attrition machines.

Hazards. *Brush machines*, construction of dust box and protection. *Attrition machines:* method of conveying and feeding; magnets in spouts at machine. *Paraffin*, how heated and used. *Threshing*, methods of removing chaff. *Dust room*, location and arrangement. *Dust*, blown outside.

Special Precautions. Spark at attrition machine igniting the dust.

RUBBER MILLS

Processes. Reclaiming (grinding, drying, devulcanizing); compounding, churning, spreading, varnishing, vulcanizing, pressing, hardening.

Hazards. *Reclaiming:* kind of stock used; wet or dry process. *Grinding:* method; machines provided with magnets; storage of ground stock. *Devulcanizing:* method; location. *Dryers:* location; arrangement; method of heating; kept clean. *Compounding:* materials used; where stored; lampblack and oxides cared for. *Churning:* room cut off or detached; properly ventilated; machines grounded; method of conveying compound to spreading or making rooms. *Naphtha:* main supply where stored; quantity; how handled; quantity in churn room at one time. *Varnishing:* where done; cut off; varnish where mixed and main supply where stored. *Spreading:* location; cut off; type; grounded; steam jets at spreaders; wet burlap nearby. *Heaters:* location; construction; cut off; how heated; steam jets. *Presses*, how heated. *Hardening:* carbon bisulphide used; if so, where and how stored.

Special Precautions. Churn room fires due to presence of naphtha fumes, caused by spark, etc. Spreaders improperly grounded. Spontaneous ignition of ground stock and reclaimed stock in dryers.

SHIRT, COLLAR, AND CUFF FACTORIES
(INCLUDING STEAM LAUNDRIES)

Processes. Shrinking, cutting, stamping, turning, stitching, laundering, finishing, and examining. Laundry work consists of washing, bleaching, bluing, starching, drying, and ironing.

Hazards. Steam heated *shrinking rooms.* Care of *cutting room waste.* Gas heated *turning machines.* Steam heated *laundry dryers*, with or without blower system. Coal, gas, or electric heated *sad irons*, or ironing machines. Gas heated *curling or edging machines.* Use of *gasoline gas* from own plant. *Charcoal* used or stored.

Special Precautions. Dryers poorly constructed of combustible material; not kept clean; and clothes placed on racks and put into dryer in such a manner that they are liable to fall on steam pipes. Recommend concrete floors, and wire netting over steam pipes. Gas or electric heated sad irons left turned on.

SHOE FACTORIES

Processes. Cutting uppers, stitching uppers, etc.; cutting, trimming, and preparing soles; cutting, pasting, pressing, and drying heels; cutting, stiffening, pressing, and drying counters and box toes; tacking insole, box toe, counter, and uppers to the last; lasting; trimming off surplus leather at bottom of uppers; sewing on welts; trimming and hardening welt into position; filling up the space between welt on bottom of shoe with cement and cork; cementing the outsoles in position; trimming edges and forming channel in the sole to receive the stitching; stitching the outsole to the welt; cementing channel lip down to cover stitches; leveling; heeling; trimming heels, edges of sole; buffing off the leather; finishing (waxing, buffing, and polishing); treeing; cleaning; inserting laces; packing and shipping.

Hazards. *Pasted heels:* paste how heated, drying. *Cutting board scrapings*, how cared for. *Rubber cement:* main supply stored where; amount in factory; how used; safety cans; open lights nearby. *Naphtha:* main supply stored where; safety cans used. *Cork filling:* where used; mixed with naphtha compound. *Oil proof*, or other compounds using naphtha. *Wax cups*, how heated. *Wood alcohol used:* where stored; used for lamps in heating wax or shoe tools. *Buffing dust*, how disposed of. *Wax filling for heels*, how heated. *Shoe dryers*, how heated and arranged. *Lampblack*, where stored. *Polish making:* wax heated; turpentine used. *Stain or edge blackings*, naphtha used for mixing or thinning. *Edge setters*, how heated; D & G or other gasoline carbureter used. *Shoe or kit tools*, how heated. *Waste chute:* location; construction; doors; discharges where. *Cement and oil house:* location; distance from factory; construction; method of handling material and bringing it into factory.

Special Precautions. General and careless use of naphtha and cement. Care of cutting board scrapings and sweepings.

WOMEN'S STRAW AND FELT HAT FACTORIES

Processes. Bleaching, dyeing, drying, sewing, sizing, blocking and trimming of straw hats; carding, shaping, stiffening, shrinking, sizing, blocking, varnishing, pressing, lauring, trimming of felt hats.

Hazards. Straw braid and felt *stock*, where stored. *Bleaching:* where done; detached; cut off, or fireproof room. *Sodium peroxide*, stored where. *Sulphur pots*, how arranged. *Drying rooms*, where located and how heated. *Sizing:* how cut; borax or alcohol shellac. *Spelter blocks*, where cast. *Blocks*, how heated. *Presses*, how heated. *Varnishing:* where done; room ventilated. *Laure stoves:* where located and how installed; method of heating; location of grease pot.

Special Precautions. Storage of straw stock. Installation of gasoline gas systems.

SUGAR REFINERIES

Processes. Mixing, bag filtering, open boiling, purifying through bone black, vacuum boiling, settling, open air drying and rotary dryers, cutting,

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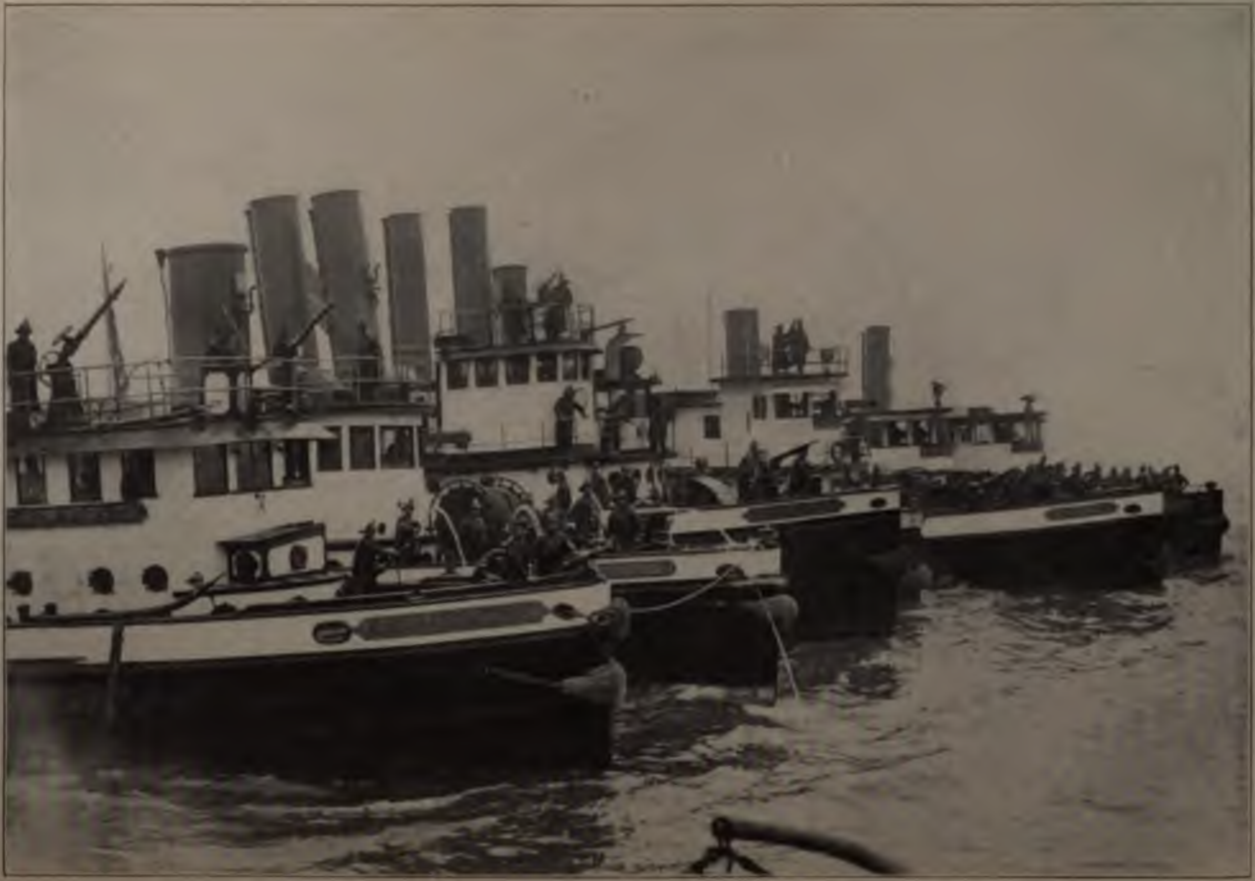

FLEET OF NEW YORK CITY FIRE BOATS
"The New Yorker" Shown in the Foreground Is the Largest and Most Complete of Any in the Service

grinding, pulverizing, packing, revivifying bone char, drying sugar bags.

Hazards. *Unslaked lime:* where stored; amount in building and method of handling. *Char house:* fire-resistive construction; cut off. *Char kilns:* location; construction; method of heating. *Bone black:* where cooled; construction of floor. *Vacuum boiling,* steam pipes well arranged. *Dry rooms:* location; construction; heating. *Grinding and pulverizing:* cut off or separate building; dust properly cared for; conveyors and hoppers of metal. *Grinding and cutting* machines enclosed in iron frames. *Sugar bags:* dried in main buildings; location and construction of dryer.

Special Precautions. Char kilns poorly constructed and not cut off.

TANNERIES AND CURRY SHOPS

Processes. Tanning processes: soaking, liming and sweating, beaming, unhairing and slating, fleshing, puring or bating, tanning, vegetable, mineral, or oil. Currying and finishing processes: splitting or slitting, stuffing or oiling, slicking or stoning, coloring, skiving, shaving, whitening, buffing, drying, staking, perching, softening, seasoning and dressing, glazing, rolling, glossing, pebbling, ironing, etc., extracting and pressing, bark grinding and leaching.

Hazards. *Lime:* where slacked; main supply where stored. *Fleshings and whitenings:* how often cleaned up; where stored. *Methods of tanning,* especially bark or chrome. *Stuffing and oiling:* where done; method of heating; oils and greases where stored; floor protection. *Buffing:* where done; dust removed by blower system, where deposited; room cleaned daily. *Drying:* method and arrangement; location and care of fans; bearings accessible; emergency shut-off; steam coils clear of combustible material. *Irons, embossing machines, etc.:* how heated and safeguarded; gas shut-off or pilot lights on electric system. *Grease extracting,* naphtha process or heat and pressure. *Bark mill:* location; cut off; wooden or metal conveyors; water spray method of conveying ground bark to leach house.

Special Precautions. Naphtha process grease extracting allowed only in well detached building. Only all iron vertical bark mills with outside gears should be used; old style wooden boxed mill with inside gearing is a prolific source of fires.

TOBACCO FACTORIES

Processes. Cleaning, dusting, curing or drying, sweating, grading, prizing, stemming, cigar making (hand or machine), cigarette making, plug tobacco making, snuff making.

Hazards. *Curing or drying,* presence of matches. Liability to *spontaneous ignition. Licorice kettles,* steam heated or open fire. *Grinding or granulating* machines provided with magnets, methods of handling dust. *Method of fumigation* against insects.

Special Precautions. Dryers, natural or artificial; type of construction and arrangement; nature of bearings; arrangement of steam pipes; metal cooling section flues; interior of dryers readily accessible; provided with steam jets.

WASTE AND BATTING (Wadding) MILLS

(INCLUDING MATTRESS FACTORIES)

Processes. Handling of cotton bales, storage of loose cotton in bins, storage of rags and waste, dusting, willowing, mixing, lumping, lapping and rag picking, garneting, carding, drying, mattress stuffing, feather steaming, crushing and cutting.

Hazards. *Cotton bale* fires. *Sparks or matches* in loose cotton. *Spontaneous ignition* in rag and waste storage. *Foreign substance* in dusters; friction in willowers; garneting; carding; drying and picking machines.

Special Precautions. Picker house fires very numerous. Working and storage of highly inflammable low grade stock.

WOODWORKERS

The general class of woodworkers may be subdivided into a number of broad divisions, but many processes and hazards are common to each. An enumeration of the prominent causes of special hazard fires gives a general idea of the processes and the over-lapping of the hazards involved.

The following figures have been compiled from the published records of the National Fire Protection Association and give the approximate percentage of fires caused by each special hazard referred to the total fires of that nature in each case.

Saw Mills. Dry kilns, 45%; sawdust vaults, 22%; refuse burners, 18%; emery grinding, 5%; power forge, 5%; band sawing, 5%.

Planing Mills. Shavings vaults, 45%; dry kilns, 30%; planing and moulding, 10%; sawdust blower system, 10%; sawing, 5%.

Box Factories. Sawdust vaults, 65%; dry kilns, 30%; sawdust blower systems, 5%.

Pails and Woodenware. Sawdust vaults, 17%; dry kilns, 66%; finishing rags, 17%.

Hardwood Turning. Dry kilns, 46%; blower systems, 22%; sawdust vaults, 8%; glue pots, 8%; finishing rags, 8%; emery grinding, 8%.

Furniture and Cabinet Factories. Dry kilns, 21%; shavings vaults, 20%; sawdust conveyor, 3%; woodworking machines, 1%; sandpapering, 4%; glue pots, 3%; caul and dry boxes, 1%; dip tanks, 10%; hand varnishing, finishing and painting, 7%; rubbing and finishing rags, 26%; upholstering, 1%; packing, 1%; oil room, 1%.

Musical Instrument Factories. Dry kilns, 30%; shavings vaults, 15%; shavings and sawdust conveyors, 5%; planing, 2½%; sandpapering, 2½%; glue pots, 2½%; oil and varnish storage, 2½%; dip tanks, 2½%; rubbing and finishing rags, 38%.

Miscellaneous Woodworkers, not otherwise enumerated. Sawdust vaults, 52%; dry kilns, 40%; turning lathes, 4%; finishing 4%.

Hazards. *Waste burner:* type; location. *Sawdust:* how cared for; blower system; fed direct to boilers or to vault; automatic dampers. *Sawdust vault:*

construction; location; cut off; openings to same from outside. *Chutes or conveyors:* construction; location. *Glue pots,* how heated. *Dry kilns or rooms:* construction; location; how heated; steam pipes or blower system properly arranged; blower clean and well oiled and cared for. *Caul boxes:* construction; how heated; steam pipes against woodwork; clean. *Woodworking machines,* connected with blower system. *Sandpapering machine:* where located; how arranged. *Oils, varnish, fillers, turpentine:* amounts used; where stored; metal or wood barrels; how thinned. *Benzine or naphtha:* main supply stored; how much used and where; open lights. *Dip tanks:* size; location; number; construction; automatic covers; overflow pipes. *Oil room,* construction and location. *Cleaning or rubbing rags,* how cared for. *Excelsior:* where used; main supply stored. *Bending or embossing machines,* how heated.

Special Precautions. Sparks in shavings vault or fuel in front of boilers. Arrangement and care of dry kiln. Handling and care of cleaning and finishing rags.

WOOLEN MILLS

Processes. Carbonizing, scouring, bleaching, dyeing, stock drying, picking, stock blowing, garneting, dusting and willowing, carding, spinning, slashing, weaving, cloth finishing.

Hazards. *Stock used:* where stored; waste in separate detached building. *Rag carbonizing:* wet or dry system; location and cut-offs; type and arrangement of bakers; construction and arrangement of carbonizing furnace; type and method of heating of dryers. *Bleaching:* method and where done; construction and arrangement of sulphur pots; danger of overturning and igniting inflammable material; liability of combustible material falling into pots. *Stock dryers:* location; construction; method of heating. *Pickers:* rag, shoddy, burr, lumpers and mixers; location; cut off; arrangement and protection of gauze room; kind of oil used. *Stock blowing system,* hand fed or connected to pickers. *Garnet machines,* where located. *Dusting:* where done; method of handling and disposing of dust; general cleanliness. *Carding,* class of stock worked. *Cloth dryers:* location; type and how heated. *Napping,* care of lint.

Special Precautions. Picking, stock drying, carding.

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REVIEW QUESTIONS

ON THE SUBJECT OF

FIRE INSURANCE INSPECTION

PART I

---

1. Give the advantages of written over oral reports.

2. Under what circumstances and for what reason are steam pipes considered dangerous fire hazards?

3. How is a dynamo represented by symbol? What are the particular points to be considered in describing the generator and its location? In describing incandescent and arc lamps?

4. Show how a floor occupancy in the first and second floors of the basement, the first to fourth floors inclusive, the sixth, and part of the seventh floors, would be indicated.

5. What are the particular points to consider in describing a gas lighting system?

6. Give the symbol for a frame building with brick side walls and stone front.

7. How are skylights described? What is the symbol for an ordinary skylight?

8. Name the fire protection devices which may or may not be found in a risk and state what each includes.

9. How is an iron-covered building represented?

10. Name the three standard report forms and give the characteristics of each.

11. Give the conventional symbol for a parapet wall; a standard fire shutter; a wire glass window.

12. Referring to the Inspector's map, interpret every symbol in the diagram of the *main building* and the piping in Georgia Avenue.

13. What determines an insurable interest?

REVIEW QUESTIONS

ON THE SUBJECT OF

FIRE INSURANCE INSPECTION

PART II

---

1. What are the worst hazards in connection with the painting of the exterior or interior of a building?

2. In a mill constructed factory how is the power house treated with reference to the main portion of the factory?

3. What are the most acceptable roof coverings from the standpoint of cost and fire protection?

4. What is meant by the term *floor opening;* why are they so important from a fire insurance standpoint?

5. Give the main varieties of building stone and their characteristics.

6. Give the general features of an approved one-story storehouse of mill construction.

7. What are *scuppers*, and for what are they used?

8. What are some of the main characteristics of mill construction?

9. Describe briefly the manufacture of roofing tin.

10. What are the requirements regarding all floor openings in mill constructed buildings?

11. Describe the attachments for a self-closing fire door.

12. What is the composition of lime mortar? Of cement mortar?

13. Give the characteristics of desirable stair construction.

14. What is the use of a "tower" for stairways, etc., in an approved four-story mill constructed factory, and how is it constructed with reference to the rest of the building?

REVIEW QUESTIONS

ON THE SUBJECT OF

FIRE INSURANCE INSPECTION PART III

1. Give a general description of the Underwriters' requirements for sprinkler heads; also give the names of some of the best.

2. How many sprinklers are allowed when a six-inch pipe is used?

3. When a cistern is used as a pump supply and is filled from the city mains, what size pipes should be used and how should they be filled?

4. Give a complete description of a pressure tank, explaining the advantages and disadvantages. State at what point the tank should be located.

5. What is a steamer connection and in what two ways is it usually fitted? If there is more than one riser, where should the steamer connection be made?

6. Describe the Grinnell variable-pressure alarm valve and make a sketch showing the valve in open position.

7. What types of dry pipe valves are approved by the National Board of Fire Underwriters? Describe a few of the principal points of each of these types.

8. In the maintenance of a sprinkler system why is it best to have central station supervision?

9. What are the methods of an inspector in testing sprinkler heads? If the first test fails, what further must be done?

10. Has the use of perforated pipe been successful in the past, and what is the most satisfactory system now in use?

11. To what use is wire glass put and what are its general advantages? Are there disadvantages in its use and if so what are they?

12. Are chemical extinguishers satisfactory as a rule? Name and describe one of the best of this type.

REVIEW QUESTIONS

ON THE SUBJECT OF

FIRE INSURANCE INSPECTION PART IV

1. Describe briefly the laws of hydrostatics and explain what you understand by Pascal's Law.

2. The piping system of a city building is connected to the city water main, which has a pressure of 34 pounds per square inch. Under this pressure how high will the water flow in the piping system of the building?

3. With a twelve-inch pipe discharging 800 gallons per minute what is the loss of head in feet for each 1,000 feet of pipe?

4. If in practice pumps will ordinarily lift water about .8 of the height given for a perfect vacuum, what would be the height of the lift in feet where the pressure is 14.1 pounds and what would be the height in feet above sea level under such conditions?

5. Make a freehand sketch of a double-acting plunger pump and explain briefly its action.

6. What are the methods of operating rotary pumps and what are the advantages of this style of pump over reciprocating pumps? Is this type of pump approved by the Board of Underwriters?

7. Give in a few words your opinion as to the best requirements for boilers for fire engine use.

8. If you were engaged to locate and construct a pump house in a small town, how would you go about it? Give your reasons for the position you would select and your methods of construction.

9. Describe the principal points to be considered in designing a distributing system over any particular part of a city or town.

10. How can the velocity and the amount of flow of water be obtained by means of the Venturi meter?

REVIEW QUESTIONS

ON THE SUBJECT OF

FIRE INSURANCE INSPECTION PART V

---

1. Write out a brief description of the duties of the building and electrical departments of a city.

2. In cities where the buildings are high, what is the usual method of training the firemen?

3. Name and describe the various divisions of the fire department of a city.

4. What are the best arrangements to provide for the equipment and men in large fire-engine houses?

5. Why should the cost of maintenance of automobile fire apparatus be less than in the case of horse-drawn fire engines?

6. Describe a typical fire boat and equipment and explain why it is designed and constructed to draw but little water and to be easily controlled.

7. In the case of cotton-covered hose what pressure should the test show according to the National Board requirements for two jackets or plies, separate or interwoven?

8. Name a few devices in use in fire departments as time savers.

9. Where would be the best site for a central office building in a city? Give reasons for your opinion.

10. Write an outline of about 500 words, giving your ideas about high pressure systems, stating advantages and disadvantages of those in present use and what you think of the future for such systems.

11. Name five of the principal cities of the United States having high-pressure fire service and explain what sources of pressure are used in each in addition to the pumping station and equipment.

REVIEW QUESTIONS

ON THE SUBJECT OF

FIRE INSURANCE INSPECTION PART VI

---

1. Explain in a few words the meaning of common hazards and of special hazards, and also the difference between the two.

2. Name an example of a common fire hazard and describe briefly.

3. What is the safest illuminant known and is it safe under all conditions?

4. Is it considered safe to install acetylene gas machines inside of buildings? If so, under what conditions?

5. State briefly the cautions that should be used by the owner of an acetylene generating system.

6. Make a sketch of a complete installation of a gasoline lighting system, naming the principal parts.

7. What is the chief hazard in the case of gasoline vapor lighting systems?

8. Explain hazards of stoves and describe how stoves should be protected.

9. Write out in your own words a short outline of how hot steam pipes may cause fires and what special care must be taken to prevent them.

10. In a combination heating and ventilating system, what natural forces are utilized as a means of operation?

11. Name and give a short description of a few specially hazardous heating arrangements.

12. How many types of alcohol stoves are in general use today? Describe the operation of such stoves. In your opinion are they dangerous?

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